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COMPOUND INDEX

This Index is mainly an index of compound classes, not of individual compounds. The headings refer to Functions or specific Atom Groups in the Molecule, to Ring Systems, and to classes of Natural Products or certain other Products of practical interest.

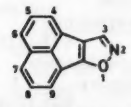
Carboxylic acid derivatives are indexed under general headings such as Carboxylic Acid Amides, Carboxylic Acid Esters, etc., or under more specific headings referring to the structure such as Alkanamides, Alkenamides, Alkynamides, Arenecarboxamides, Alkanoic Acids, etc.

Cyclic Compounds are indexed as follows:

- Isolated isocyclic rings under the heading of the pertaining cyclic saturated or unsaturated hydrocarbon
- Fused bi- and polycyclic carbocyclic compounds and heterocyclic compounds under the heading of the parent unsaturated cyclic system. In the case of heterocyclic oxo derivatives, the "one" nomenclature is not used; these compounds are indexed as oxo derivatives of the corresponding *H*- or Hydro compounds.
- Bridged and small-ring bicyclo-, tricyclo-, etc. compounds are indexed under the heading of the parent saturated ring system.
- Spiro compounds are indexed under the heading of the "senior" ring component.

For reasons of brevity, compounds containing certain unsubstituted positions are in some cases designated as *H*-compounds. Thus, for example, aliphatic aldehydes having available hydrogen at C-α are simply named "2*H*-alkanals".

● **Acenaphtho[1,2-*d*]-1,2-oxazole**



- 3a, 9a-Dihydroacenaphtho[1,2-*d*]-1,2-oxazoles
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– 3-phenyl der. 158

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– benzylaminoacetaldehyde dialkyl acetals from phenols, formaldehyde, and aminoacetaldehyde dialkyl acetals 769
– cyclic acetals from aldehydes and 1,2- or 1,3-diols 185 (2764)
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– formaldehyde dialkyl acetals from alcohols, dimethyl sulfoxide, and *N*-halosuccinimides 802 (3245)
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– 2,2,2-trichloroethyl acetals from dimethyl- or diethyl acetals, trichloroethanol, and tosic acid 798 (3230)
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– – with paraformaldehyde 433 (2951)
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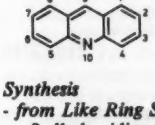
– *CH*-acidic ketones + 4-alkoxy-(or hydroxy)-hexahydropyrimidine der. 266
– alkyl 2-oxocyclopentanecarboxylates + alkyl halides + base 316
– 5,5-dimethyl-1,3-dioxocyclohexane + 2-acylamino-2-chloro-1,3-dioxoindanes + triethylamine 154
– malonic acid der. + 1-morpholinocyclohexene 803 (3248)
– phenylacetic acid der. + formaldehyde 433 (2951)
– phenyl methylsulfonylmethanesulfonate + methylsulfonyl chloride + base 211

● **Acridine**



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- from Like Ring Skeletons
– 9-alkylacridines from acridine by radical alkylation 14
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– optically active alcohols from ketones, organocadmium compounds, and diisopropyl (+)-*O,O*-dimethyltartrate 432 (2949)
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– 2-alkenol acetates from alkenes and mercury(II) acetate 586
– 2-alkenol acetates from alkenes having allylic hydrogen and thallium(III) acetate 592
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– – from ketones and sodium acetylenide (2 steps) 460
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– 2,2-dialkoxyalkanols from 2,2-dialkoxyaldehydes by catalytic hydrogenation 278
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– – from *CH*-acidic compounds and paraformaldehyde 433 (2951)
– – from trialkylboranes, carbon monoxide, and hydrogen peroxide 653
Reactions
- *Cyclization Reactions*
– linear alcohols + cerium(IV) ammonium nitrate 348
– linear alkanols + lead(IV) acetate 406
- **Secondary Alcohols**
Synthesis
- *from Like Carbon Skeletons*
– – from ketones and polymethylhydrosiloxane 803 (3251)
– cycloalkanols from cycloalkanones and potassium triisopropoxyborohydride 801 (3242)
– stereoregular cycloalkanols from cycloalkanones and lithium tri-*sec*-butylborohydride *in situ* 626 (3110)
- *from Unlike Carbon Skeletons*
– – from 1-alkynes by dihydroboration. alkylation, and oxidative hydrolysis 37
– 3-hydroxy-1-(2-pyridyl)-alkanes from 1-cyano-1-(2-pyridyl)-cyclopropanes 204
- **Tertiary Alcohols**
Synthesis
- *from Unlike Carbon Skeletons*
– – from trialkylboranes by hydrolysis, bromination, and irradiation 645
– – from trialkylboranes, carbon monoxide, and water 652
– 4-butyl-4-hydroxynonane 641
– 2-(2-pyridylethyl) carbinols from 1-cyano-1-(2-pyridyl)-cyclopropanes 204
Reactions
- *without Cyclization*
– – with (1.) formic acid/sulfuric acid, (2.) methanol 554 (3054)
– – with trimethylaluminum 228 (2781)
– cyano-*t*-butanol + carbonyl chloride + pyridine 240 (2834)
- **Triarylcarbinols and Hetero Analogs**
Synthesis
- *from Like Carbon Skeletons*
– triphenylcarbinol acetates from triphenylmethanes and lead(IV) acetate 568
- *from Unlike Carbon Skeletons*
– triphenylcarbinol 348
● **Aldehydes**
- General
- *from Like Carbon Skeletons*
– – from acyl chlorides and sodium tetracarbonylferrate 229 (2786)
– – from aldehyde, *S,S*-acetals and *O*-mesitylhydroxylamine 312
– – from aldoximes and aluminum triisopropoxide 433 (2952)

– – from *prim*-alkylamines and 2-formyl-1,3-benzothiazoles (3 steps) 230 (2789)
– – from *N*-alkyl-*N*-nitroso-tosylamides 59 (2620)
– – from *prim*-alkyl trityl ethers and triphenylcarbenium salts 806 (3262)
– – from cyclic *S,S*-acetals and thallium(III) trifluoroacetate 499 (2994)
– – from primary alcohols and cerium(IV) ammonium nitrate 347
– – from primary alcohols and dimethyl-(succinimido)-sulfonium chloride 628 (3118)
- from Unlike Carbon Skeletons
– – from secondary alcohols and cerium(IV) ammonium nitrate 347
– aliphatic aldehydes from 2-lithiomethyl-4,5-dihydro-1,3-thiazole and alkyl halides 553 (3048)
– α,α-dialkyl-substituted aldehydes from 2-alkylalkanals and alkyl chlorides 805 (3260)
Reactions
– – cycloacetalization with diols 185 (2764)
– – with alkyl thiocyanato-acetates + base 373 (2916)
– – with amine hydrochlorides + potassium cyanide 735
– – with cerium(IV) ammonium nitrate 348
– – with cyanotrimethylsilane 814 (3298), (3299)
– – with trimethylsilyldiazo-methane + base 685 (3160)
– α*H*-aldehydes + lead(IV) acetate 577
- Alkanals
Synthesis
- from Heterocyclic Compounds
– – from 2-alkyltetrahydro-1,3-thiazoles and aqueous mercury(II) chloride 553 (3048)
– 4-formyloxybutanal 66 (2647)
- from Unlike Carbon Skeletons
– – from 1-alkanals and trialkyl-borane 657
– from 1-alkenes, carbon monoxide, and hydrogen (+ octacarbonyl-dicobalt catalyst) 177 (2728)
Reactions
- involving the Formyl Group
– – Mannich reactions with formal-dehyde and higher aldehydes 703
– 2*H*,2*H*-alkanals + *N,N'*-disubstituted ureas + acid 265
– 2*H*-alkanals + guanidines + acid 262
– 2*H*-alkanals + thioureas + acid 262
– 2*H*-alkanals + thioureas + alcohols + hydrogen chloride 262
– 2*H*-alkanals + ureas + acid 262
– 2*H*-alkanals + ureas + alcohols + hydrogen chloride 262
– formaldehyde + 1,2-diaminoethane + sulfamide 253
– formaldehyde + sulfamide + ammonia or alkylamines 253
- not involving the Formyl Group
– 2*H*-alkanals + 4-alkoxy-2-oxo-hexahydropyrimidines + acid 266
– 2*H*-alkanals + 1,3-bis[hydroxy-methyl]-2-oxohexadropyrimidines + acid 277
– 2*H*-alkanals + 4-hydroxy-2-oxo-hexahydropyrimidines + acid 266
– 2-branched alkanals + alkyl chlorides + base 805 (3260)
– 2-branched alkanals, amino-methylation by Mannich reaction 733
– α-unsubstituted aldehydes + alkane-1,2-bis[sulfenyl chlorides] 120 (2701)
- 2-Alkenals
Synthesis
-from Like Carbon Skeletons
– 2-alkylpropenals from 2-amino-methylakanals by deamination 747
– pentadienals from 5-dialkyl-amino-2-pentenals, thermally 748
- from Unlike Carbon Skeletons
– – from ketones and ethoxy-ethynylmagnesium bromide (3 steps) 460
– 2-alkyl-5-dialkylamino-2-alkenals from 2-alkyl-2-alkenals, formal-dehyde, and dialkylamines 733
– 2-dialkylamino-3-dimethyl-aminoacroleins from 1,2-bis-[dialkylamino]-ethylenes and *N,N*-dimethylchloromethaninium chloride 629 (3124)
– 3-ferrocenylpropenal 530
– 2-methoxyacrolein 104
– 8-oxo-2-alkenals from cyclo-hexenes and α-chloro-aldehyde *N*-cyclohexylnitrones 500 (2997)
Reactions
- involving the Formyl Group
– – with 1,4-quinones + ethoxy-magnesium bromide 369 (2897)
– – with sulfamide + acid 290
– – with ureas 289
- not involving the Formyl Group
– 2-alkyl-2-alkenals, amino-methylation by Mannich reaction 733
– two-stage reduction of the C=C double bond with tertiary silanes + tris[triphenylphosphine]-rhodium chloride 686 (3164)
- 4-Alkenals
Synthesis
- from Unlike Carbon Skeletons
– 2,2-dialkyl-4-alkenals from 2-branched alkanals and 1-chloro-2-alkenes 805 (3260)
- 5-Alkynals
Synthesis
- from Unlike Carbon Skeletons
– – from 2,3-epoxycyclohexanones and tosyl hydrazide 500 (2996)
– – from α-oxo cyclic epoxides and 1-amimoaziridines 434 (2956)
- Allenic Aldehydes
Synthesis
– 2,2-dimethyl-3,4-hexadienal 30, 32
– 3,4-hexadienal 34
- α-Amino-Aldehydes
Reactions
- involving the Formyl Group
– 2-alkylminoalkanals + dialkylamines 179 (2734)
- β-Amino-aldehydes
Synthesis
- from Unlike Carbon Skeletons
– 2-aminomethylalkanals from 2-branched alkanals, formal-dehyde, and dialkylamines 733
– 2,2-dimethyl-3-(3-methyl-2-oxohexahydro-1-pyrimidyl)-propanal 277
– hexahydropyrimidine-4-acet-aldehydes from 4-alkoxy(or hydroxy)-2-oxohexahydropyri-midines and 2*H*-alkanals 266
Reactions
- involving the Formyl Group
– 3-alkoxycarbonylaminopropanals + ammonia or primary amines + hydrogen/Raney nickel 279
– 3-ureidopropanals + ammonia or primary amines + hydrogen/ Raney nickel 279
- Aromatic Aldehydes
Synthesis
- from Heterocyclic Compounds
– benzaldehyde 353
- from Like Carbon Skeletons
– benzaldehydes from benzoic acids by electrochemical reduction 116 (2684)
– benzaldehydes from benzyl alcohols and nitric acid 229 (2787)
– benzaldehydes from methyl-benzenes and cerium(IV) ammonium nitrate 351
- from Unlike Carbon Skeletons
– – from arenes and hexamethylene-tetramine/trifluoroacetic acid acid 552 (3044)
– – from 1,2-diaryl-1,2-dihydroxy-ethanes and thallium(III) nitrate 806 (3266)
Reactions
- involving the Formyl Group
– benzyldehyde + tetrabutyl-aminium cyanide 451
– benzaldehydes + bis[trimethyl-silyl]-mercury 318 (2849)
– benzaldehydes + lithium/ ammonia 227 (2777)
– 3,4-dihydroxybenzaldehydes + phenylacetic acids + piperidine 499 (2995)
– 3-methoxybenzaldehyde + lithium alanate 796
– vanillin + methyl ketones + pyrrolidine/acetic acid 499 (2993)
- α-Aryl-aldehydes and Hetero Analogs
Synthesis
- from Unlike Carbon Skeletons
– – from benzoins or analogs and cerium(IV) ammonium nitrate 348
– – from α-hydroxyphenylacetic acids and cerium(IV) ammonium nitrate 350
Reactions
- involving the Formyl Group
– triphenylacetaldehyde + cerium(IV) ammonium nitrate 348
- Dialdehydes
Synthesis
- from Unlike Carbon Skeletons
– – from 1,2-dihydroxycyclo-alkanes and manganese(IV) oxide 805 (3258)
– adamantylmalondialdehydes from (2-methoxyethenyl)-adamantanes, dimethylform-amide, and oxalyl chloride 604
– dialkylaminomalondialdehydes from 1,2-bis[dialkylamino]-ethylenes and *N,N*-dimethylchloro-methaniminium chloride (3 steps) 629 (3124)
– dimethylaminomalondial-dehyde 804 (3255)
– 2-octenedials from cyclohexenes and α-chloro-aldehyde *N*-cyclo-hexylnitrones (4 steps) 500 (2997)
– 2-oxohexahydropyrimidine-1,3-dipropanals from 1,3-bis[hydroxy-methyl]-2-oxohexahydropyrimi-dines and 2*H*-alkanals 277
Reactions
– 1,3-dialdehydes + ureas 257

– *o*-phthaldialdehyde + nitrobenzenes + carbon monoxide + hexadecacarbonylhexarhodium 323 (2871)
- α-Halo-aldehydes
Reactions
- *involving the Formyl Group*
– – with dialkylamines + arsenic(III) chloride 686 (3166)
– α-chloro-aldehydes + cyclohexylhydroxylamine 552 (3046)
- Heterocyclic Aldehydes
Synthesis
– from *C*-methyl heterocyclic compounds via the corresponding 1-methylpyridinium iodides 482
– chromon-3-carbaldehydes from 2-hydroxyactophenones, dimethylformanide, and phosphoryl chloride 699 (3216)
– *N*-heteroarenecarbaldehydes from *N*-heteroarenes, 1,3,5-trioxane, and hydrogen peroxide 687 (3167)
– pyrrole-3-carbaldehyde 422
Reactions
– 5-dialkylaminofurfurals + phosphoryl chloride 621
– 5-dialkylaminothiophene-2-carbaldehydes + phosphoryl chloride 621
– 5-dialkylaminothiophene-2-carbaldehydes + tosic acid 621
– 5-dimethylaminoselenophene-2-carbaldehyde + tosic acid 621
– 5-methylfurfural + lithium alanate 796
- α-Hydroxy-aldehydes and *O*-Derivatives
Synthesis
- *from Like Carbon Skeletons*
– α-acetoxy-aldehydes from α*H*-aldehydes and lead(IV) acetate 577
- *from Unlike Carbon Skeletons*
– – from 2-lithiomethyl-4,5-dihydro-1,3-thiazole and aldehydes or ketones 553 (3048)
– 2-aryl-2-hydroxyalkanals from alkyl aryl ketones and butyllithium/dichloromethane 230 (2788)
– α-hydroxy-arylacetaldehydes from benzaldehydes and the lithio der. of methyl methylthiomethyl sulfoxide 177 (2728)
– α-hydroxy-diarylacetaldehydes from benzophenones and the lithio der. of methyl methylthiomethyl sulfoxide 177 (2728)
- β-Hydroxy-aldehydes and *O*-Derivatives
Synthesis
- *from Unlike Carbon Skeletons*
– – from 2-lithiomethyl-4,5-dihydro-1,3-thiazole and oxiranes 553 (3048)
Reactions
- *involving the Formyl Group*
– 3-hydroxybutanal + *N,N'*-dimethylurea + acid 289
- γ-Hydroxy-aldehydes and *O*-Derivatives
Synthesis
- *from Unlike Carbon Skeletons*
– – from 2-hydroxymethyl-1-alkenes, carbon monoxide, hydrogen, and rhodium catalysts 696 (3206)
- β-Oxo-aldehydes
Reactions
- *involving the Formyl Group*
– – with ureas 257
- γ- Oxo-aldehydes
Synthesis
- *from Like Carbon Skeletons*
– 4-oxoalkanals from 2-alkyl-2-[2-(1,3-dioxolan-2-yl)-ethyl]-tetrahydro-1,3-oxazines and acid 410
- Miscellaneous Types
Synthesis
– α-ferrocenyl-aldehydes from acylferrocenes and dimethylmethylenesulfurane 806 (3263)
– adamantane-2-carbaldehyde 604
● Alkaloids and Relatives
- Berberine-Type Alkaloids
Synthesis
– protoberberine der. from 1-(2-hydroxybenzyl)-1,2,3,4-tetrahydroisoquinolines and formaldehyde 723
- Ergot Alkaloids
Synthesis
– 5-(1,3-dithiolan-2-yl)-lysergic acid methyl ester 65 (2645)
- Ipecacuanha Alkaloids
Synthesis
– 1',2'-secoemetine 544
- Pachysamine-Type Alkaloids
Isolation
– pachystermine A und B 327
- Reserpine-Type Alkaloids
Synthesis
– 7-chloro-7*H*-deserpidine 242 (2841)
Reactions
– deserpidine + 1-chlorobenzotriazole 242 (2841)
● Alkanamides
- General
Synthesis
– *N*-alkoxy-*N*-methylalkanamides from *N*-methylalkanamides and alcohols, electrochemically 808 (3274)
Reactions
– – with tetrafluoroboric acid 810 (3280)
– *N*-alkyl-2*H*-alkanamides + *N,N*-dimethyldichloromethaniminium chloride 371 (2906)
- Acetamides
Synthesis
– – from formamides and bismuth(III) acetate 809 (3279)
– – from primary amines and bismuth(III) acetate 809 (3279)
– *N*-alkylacetamides from *N,N*-dimethylacetamide and alkylamines 361
- 2-Amino-alkanamides
Synthesis
– 2-benzoylaminoalkanamides from 4-alkylidene-2-phenyl-4,5-dihydro-1,3-oxazoles, hydrogen, and ammonia 629 (3125)
– *N*-methyl-(arylamino)-acetamides from *N*-methylbromoacetanilides and ammonia or primary amines 809 (3278)
- 3-Aminoalkanamides
Synthesis
– 3-acylamino-3-arylpropanamides from alkanoic anhydrides, benzaldehyde *N,N'*-diacylaminals, and ammonia 40
- 2-Arylalkanamides and Hetero Analogs
Reactions
– 2-phenylpropanamides + sodium amide 340
- Cyanoacetamides
Reactions
– – with phosphoryl chloride 563 (3089)
- Formamides
Synthesis
– alkylformamides from dimethylformamide and alkylamines 360
Reactions
– dimethylformamide + phophorus(V) sulfide 149
– *N*-substituted formamides + bismuth(III) acetate 809 (3279)
– *N*-substituted formamides + triphenylphosphine + diethyl diazenedicarboxylate 435 (2958)
- 2-Haloalkanamides
Reactions
– *N*-aryl-*N*-phenacylhaloacetamides + base 339
– *N*-methylbromoacetanilide + ammonia or primary amines 809 (3278)
- 3-Haloalkanamides
Reactions
– – cyclization with base 340
- Higher Alkanamides
Synthesis
– *N,N'*-(1,ω-alkanediyl)-bis[6-nitrohexanamides]from 2-nitrocyclohexanone and 1,ω-diaminoalkanes 627 (3115)
– 6-nitrohexanamide 627 (3115)
- 3-Hydroxyalkanamides and *O*-Derivatives
Reactions
– – with lead(IV) acetate 818 (3316)
- 4-Hydroxyalkanamides and *O*-Derivatives
Synthesis
– – from *N,N*-dialkyl-2*H*-alkanamides, sodium amide, and ammonia 179 (2736)
- 2-Oxoalkanamides
Reactions
– *N*-(2-oxoalkanoyl)-piperidines, irradiation 344
– *N*-(2-oxoalkanoyl)-tetrahydro-1,3-thiazoles, irradiation 344
- 3-Oxoalkanamides
Synthesis
– dibenzoylacetanilides from 4-benzoyl-2,3-dioxo-5-phenyl-2,3-dihydrofuran and benzylideneanilines 679
● Alkanedinitriles
- Higher Alkanedinitriles
Reactions
– – with phosphorus(V) chloride 545
- Malodinitriles
Synthesis
– bis[hydroxyphenyl]-malodinitriles from mesoxalodinitrile, phenols, and acid 671
– bis[methoxyphenyl]-malodinitriles from mesoxalodinitrile, methoxybenzenes, and acid 671
– cyclohexylidenemalodinitrile 803 (3248)
– dimethylaminomalodinitriles from dimethylaminoethoxycarbenium tetrafluoroborate and sodium cyanide 61 (2631)
- Mesoxalodinitrile (Carbonyl Cyanide)
Reactions
– – with methoxybenzenes (+ acid) 671
– – with phenols (+ acid) 671
- Succinodinitriles
Synthesis
– 1-cyanomethylcyclohexyl-phenylacetonitriles from phenylacetonitriles and cyclohexylideneacetonitrile 180 (2740)

– 2,3-diacyl-2,3-diphenylsuccinodinitriles from 3-oxo-2-phenylalkanenitriles by oxidative coupling 59 (2622)

● Alkanedioic Acid Chlorides

- Oxalyl Chloride

Reactions

– – with cyanamide 202

- Malonyl Chlorides

Reactions

– – with α-unsubstituted nitriles 193

– benzylmalonyl chloride + nitriles 193

– dimethylmalonyl chloride + cyanamide 202

– malonyl chloride + nitriles 192, 194

● Alkanedioic Acid Esters

- Higher Alkanedioc Acid Esters

Synthesis

- from Unlike Carbon Skeletons

– dimethyl octanedioates from alkenes, monomethyl malonate, and monomethyl potassiomalonate 370 (2903)

- Malonic Acid Esters and Derivatives

Synthesis

- from Like Carbon Skeletons

– diethyl acetoxymalonate 586

– diethyl *N*-alkyl-*N*-arylaminomethylenemalonates from diethyl ethoxymethylenemalonate and *N*-alkyl-*N*-arylamines 320 (2858)

– dimethyl diethylaminomalonate 144

- from Unlike Carbon Skeletons

– diethyl acetylamino-2-ethoxycarbonyl-2-hydroxyethylmalonate 44

– diethyl 2-halo-1-oxoalkylmalonates from diethyl malonate and α-haloacyl chlorides 184 (2760)

– dimethyl allylchloromalonate 145

– dimethyl methylmethoxymalonate 144

– dimethyl methylmethylthiomalonate 144

– dimethyl 2,3,4,5-tetramethylphenylmalonate 144

– monoethyl cyclohexylidenemalonate 803 (3248)

Reactions

- involving the Ester Group(s)

– diethyl *N*-arylaminomethylenemalonates, cyclization with phosphorus pentoxide 325 (2876)

– diethyl bromoethylmalonate + *N*-phenylmethanimine + zinc 331

– diethyl malonate + isocyanates + triethylamine 564 (3094)

- not involving the Ester Groups

– diethyl *N*-(3-bromopropanoyl)-anilinomalonates + base 339

– diethyl ethoxymethylenemalonate + *N*-alkyl-*N*-arylamines 320 (2858)

– diethyl *N*-haloacetylanilinomalonates + base 339

– monoalkyl malonates + 1-morpholinocyclohexene 803 (3248)

- Oxalic Acid Esters

Reactions

– dialkyl oxalates + alkali metal phenoxides 499 (2992)

- 3-Oxoalkanedioic Acid Esters

Synthesis

- from Unlike Carbon Skeletons

– diethyl 3-oxo-2-pentylpentanedioate 398

Reactions

- not involving the Ester Groups

– dialkyl acetonedicarboxylates + aromatic or heteroaromatic aldehydes + alkylamines 725

- 4-Oxoalkanedioic Acid Esters

Synthesis

- from Unlike Carbon Skeletons

– dimethyl 3-methyl-4-oxooctanedioate 213

- Succinic Acid Esters

Synthesis

- from Unlike Carbon Skeletons

– acylsuccinic acid esters from butenedioic acid esters and aldehydes 629 (3126)

– 1-alkyl 2-alkylidenesuccinates from dialkyl succinates and ketones 406

– dimethyl 2,3-dicyano-2,3-diphenylsuccinates from methyl α-phenylcyanoacetates by oxidative coupling 59 (2622)

– ethyl 1-ethoxycarbonyl-2-oxocyclopentane-1-acetate 316

Reactions

- not involving the Ester Groups

– – with ketones 406

– dimethyl alkylidenesuccinates + (1.) lithium diisopropylamide, (2.) dialkyl bromo-methylmalonates 232 (2797)

● Alkanedioic Acids

- Higher Alkanedioic Acids

Synthesis

- from Like Carbon Skeletons

– α,α,α',α'-tetrachlorodicarboxylic acids from alkanedinitriles and phosphorus(V) chloride 545

- Malonic Acids

Synthesis

– cyclohexylidenemalonic acid 803 (3248)

- Succinic Acids

Synthesis

- from Unlike Carbon Skeletons

– 2-(3-alkenyl)-succinic acids from allyl 3-alkenoates and tetracarbonylnickel 516

– 2-(3-alkenyl)-succinic acids from 1-halo-2-alkenes, carbon monoxide, water, tetracarbonylnickel, and magnesium oxide 515

● Alkanenitriles

- General

Synthesis

- from Like Carbon Skeletons

– – from 1-formylamino-1-tosyl-1-alkenes and sodium methoxide 688 (3172)

- from Unlike Carbon Skeletons

– – from alkyl halides and sodium cyanide 448

– – from chloroacetonitrile and trialkylboranes 646

Reactions

- involving the Cyano Group

– 2*H*-alkanenitriles + hydrogen chloride + carbonyl chloride 195, 197

– α-unsubstituted alkanenitriles + + *N*-(α-chlorobenzylidene)-carbamoyl chlorides 200

– α-unsubstituted alkanenitriles + malonyl chloride 193

- 2-Aminoalkanenitriles

Synthesis

- from Unlike Carbon Skeletons

– – from aldehydes, amine hydrochlorides, and potassium cyanide 735

– 2-dimethylamino-2-ethoxyalkanenitriles from 1-dimethylamino-1-ethoxycarbenium tetrafluoroborates and sodium cyanide 61 (2631)

Reactions

- involving the Cyano Group

– acylaminoacetonitriles + alkyl nitrites + acid 373 (2918)

– acylaminoacetonitriles + alkyl nitrites + acid + alcohols 373 (2919)

- 3-Aminoalkanenitriles

Synthesis

- from Like Carbon Skeletons

– 3-aminopropanenitrile 228 (2784)

– 3-anilinopropanentitriles from anilines and acrylonitrile 698 (3213)

- from Unlike Carbon Skeletons

– 3-amino-2-phenylpropanenitriles from α-cyanophenylacetaldehyde and amines (2 steps) 61 (2628)

- 2-Arylalkanenitriles and Hetero Analogs

Synthesis

- from Unlike Carbon Skeletons

– 3-amino-2-phenylpropanenitriles from α-cyanophenylacetaldehyde and amines (2 steps) 61 (2628)

– 2,2-bis[methoxyphenyl]-propanenitriles from 2-oxopropanenitrile, methoxybenzenes, and polyphosphoric acid 671

– 2,2-bis[hydroxyphenyl]-propanenitriles from 2-oxopropanenitriles, phenols, and polyphophoric acid 671

Reactions

- involving the Cyano Group

– – with hydrogen chloride/carbonyl chloride 197

– phenylacetonitrile + dialkyl sulfites (or diphenyl sulfite) + sodium amide 65 (2646)

- 2-Hydroxyalkanenitriles

Reactions

- not involving the Cyano Group

– α-hydroxyphenylacetonitrile, 2-alkylation after *O*-protection 358

– α-hydroxyphenylacetonitrile, 2-arylation after *O*-protection 358

- 2-Oxoalkanenitriles

Synthesis

- from Unlike Carbon Skeletons

– – from acyl chlorides and copper(I) cyanide 181 (2743)

Reactions

- not involving the Cyano Group

– 2-oxopropanenitrile + methoxybenzenes (+ polyphosphoric acid + 3-mercaptopropanethioic acid) 671

– 2-oxopropanenitrile + phenol (+ polyphosphoric acid + 3-mercaptopropanethioic acid) 672

- 3-Oxoalkanenitriles

Synthesis

- from Unlike Carbon Skeletons

– – from 1*H*-alkyl ketones and chlorosulfonyl isocyanate 682

– – from carboxylic anhydrides and 1-cyanoalkylzinc bromides 120 (2700)

- 4-Oxoalkanenitriles

Synthesis

- from Unlike Carbon Skeletons

– from 2-alkenenitriles and aldehydes (+ sodium cyanide) 629 (3126)

– – from 1-alkenyl ketones and hydrogen cyanide/alkylaluminum compounds 551 (3042)

Reactions

- not involving the Cyano Group

– – with 1,2-dimercaptoethane + boron trifluoride 408

- Miscellaneous Types

Synthesis

– 2-(4-methylphenylsulfonyl)-alkanenitriles from alkenes and tosyl cyanide, irradiation 182 (2750)

• Alkanes
- General
Synthesis
- from Heterocyclic Compounds
– – from 5-substituted 3-nitroso-2-oxo-1,3-oxazolidines and butylamine 799 (3234)
– – from thiophenes, sodium borohydride, and nickel(II) chloride 317 (2843)
- from Like Carbon Skeletons
– – from alkenes and 2,4,6-triisopropylbenzenesulfonyl hydrazide 366 (2884)
Reactions
– – with bromine/mercuric oxide 227 (2780)
- Arylalkanes
Synthesis
- from Heterocyclic Compounds
– diphenylmethanes from 2,2-diphenyl-1,3-dithiolanes and lithium alanate/copper(II) chloride 366 (2883)
- from Like Carbon Skeletons
– diphenylmethanes from alkyl diphenylmethyl sulfides and lithium alanate/copper(II) chloride 366 (2883)
– diphenylmethanes from diphenylmethyl phenyl sulfides and lithium alanate/copper(II) chloride 366 (2883)
– 1,3-diphenylpropanes from 1,3-diphenyl-1-oxopropanes and triethylsilane/trifluoroacetic acid 421
- from Unlike Carbon Skeletons
– 2,3-bis[2-naphthyl]-butane 53
• Alkanoic Acid Chlorides
- 3-Aminoalkanoyl Chlorides
Reactions
– – cyclization of hydrochlorides using ammonia or amines 328
- 4-Cyanoalkanoyl Chlorides
Reactions
– 4-aryl-4-cyanobutanoyl chlorides + hydrogen chloride 191
- 2-Haloalkanoyl Chlorides
Synthesis
– 2-chloro-2-chlorosulfonylalkanoyl chlorides from 2-chlorosulfonylalkanoyl chlorides and phosphorus(V) chloride 632 (3138)
Reactions
– polychloroacetyl chlorides + 2-trimethylsiloxy-1-alkenes 369 (2896)
- Miscellaneous Types
Synthesis
– 2-chlorosulfonylalkanoyl chlorides from 2*H*-alkanoic acids and phosphoryl chloride/sulfur trioxide 557 (3066)
• Alkanoic Acid Esters
- General
Synthesis
- from Unlike Carbon Skeletons
– – from alkyl diazoacetates and trialkylboranes 647
– – from alkyl halides, carbon monoxide, alcohols, and tetracarbonylcobaltates 519
– – from ethyl diazoacetate and *B*-chlorodialkylboranes 118 (2695)
- Acetic Acid Esters
Synthesis
– aryl acetates from arenes and lead(IV) acetate 574
– benzyl acetates from alkylarenes and lead(IV) acetate 568
– benzyl acetates from methylbenzenes, acetic acid, and palladium(II) salts 595
– benzyl acetates from methylbenzenes, acetic acid, oxygen, and palladium(II) salts 595
– benzyl acetates from methylbenzenes, acetic anhydride, oxygen, and silver acetate 602
– benzyl acetates from methylbenzenes and cerium(IV) ammonium nitrate 601
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- from Unlike Carbon Skeletons
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– – with fluorosulfuric acid 661
– – with potassium permanganate + quaternary aminium compounds 453
– activated 1-alkenes + *N*-phenylthiobenzenesulfenamide 228 (2784)
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– – with alkyl halides + palladium(II) acetate/amines 497 (2987)
– – with aryl halides + palladium(II) acetate/amines 497 (2987)
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- from Unlike Carbon Skeletons
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- by C=C Double-Bond Shifts
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– cyclopropylidenecyclohexanes from methyl *N*-(1-hydroxycyclohexylmethyl)-*N*-nitrosocarbamate, alkenes, and base 803 (3250)
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- involving the C=C Double Bond
– – with potassium permanganate 498 (2989)
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- Miscellaneous Types
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– methyl-substituted polycyclic alkenes from polycyclic *gem*-(benzoylamino)-methyl compounds and phosphorus(V) oxide 114 (2674)
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Synthesis
- from Like Carbon Skeletons
– methyl 4-dialkylaminocinnamates from methyl cinnamate and *N*-chlorodialkylamines 6
- from Unlike Carbon Skeletons
– – from 1-halo-1-alkenes, carbon monoxide, alcohols, and tetracarbonylnickel 517
– alkyl 2-alkoxy-2-alkenoates from aldehydes and dialkyl 1,2-dialkoxy-2-oxoalkanephosphonates 409
– alkyl tetrahydro-3-thienylidenecyanoacetates from alkyl cyanoacetates and 3-oxotetrahydrothiophene 695 (3199)
– ethyl 2-acetyl-2-alkenoates from ethyl acetoacetate and aldehydes 119 (2698)
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– methyl 3-ferrocenylpropenoate 530
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- **3-Alkenoic Acid Esters**
Synthesis
- *from Unlike Carbon Skeletons*
– – from alkyl 4-bromo-2-butenoates and trialkylboranes 646
– – from 1-chloro-2-alkenes, carbon monoxide, alcohols, and nickel catalysts 512
– – from 1,3-dienes, carbon monoxide, alcohols, and palladium complexes 521
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– – from 2,4-pentadienoic acid esters and butyl- or vinylcopper 807 (3267)
– alkyl 2-bromo-3-alkenoates from alkyl acetoacetates by 1-alkenylation, bromination, and acid cleavage 683 (3152)
– ethyl 3-siloxy-3-alkenoates from ketene *O*-ethyl *O*-(*t*-butyldimethylsilyl)-acetals and 2*H*-alkanoyl chlorides 808 (3272)
- **4-Alkenoic Acid Esters**
Synthesis
- *from Unlike Carbon Skeletons*
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- *from Like Carbon Skeletons*
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- *from Unlike Carbon Skeletons*
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– alkyl 3,8-nonadienoates from butadiene, carbon monoxide, alcohols, and palladium complexes 522
– alkyl 3,7-octadienoates from 3-chloropropene, butadiene, carbon monoxide, alcohols, and palladium salts 521
– methyl 2,5-alkadienoates from acetylene, carbon monoxide, methanol, and nickel complexes 513
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- **General**
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- *from Like Carbon Skeletons*
– – from alkynoic acids by catalytic hydrogenation 458
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- *from Like Carbon Skeletons*
– – from sodium alkanoates (linear), lithium diisopropylamide, and DDQ 688 (3174)
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– – from 1-alkynes, carbon monoxide, and water 510
– α-(4-chlorophenyl)-cinnamic acids from benzaldehydes and phenoxyacetic acids 629 (3123)
- **3-Alkenoic Acids**
Synthesis
- *from Like Carbon Skeletons*
– 2-bromo-3-alkenoic acids from their *t*-butyl esters and tosic acid 683 (3152)
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Synthesis
- *from Unlike Carbon Skeletons*
– 3-oxocyclopentene-4-acetic acid 514
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- **Acetylenedicarboxylic Acid Esters**
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- *not involving the Ester Groups*
– – with catechol + base 374 (2922)
– – with 2-imino-1,3-dithiolanes 439 (2978)
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- **General**
Synthesis
- *from Unlike Carbon Skeletons*
– – from ketones and trimethylsilyldiazomethane 685 (3160)
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– 6-oxoalkynes from α-oxo cyclic epoxides and 1-aminoaziridines 434 (2956)
Reactions
– – catalytic hydrogenation 457
– – with benzoyl chloride-aluminum chloride complexes 116 (2683)
– – with *N*-bromosuccinimide/dimethyl sulfoxide 59 (2621)
– – with dialkylboranes 429 (2935)
– – with 1a, 5a-dihydrocyclopropa[*d*]pyridazines 367 (2887)
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Synthesis
- *from Like Carbon Skeletons*
– – from 1,1-dibromo-1-alkenes and butyllithium 490 (2937)
- *from Unlike Carbon Skeletons*
– – from aldehydes and trimethylsilyldiazomethane 685 (3160)
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– – with alkoxymethyl-thioureas and acid 286
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Synthesis
- *from Unlike Carbon Skeletons*
– – from 1-alkynyllithium and triarylboranes 803 (3249)
– arylacetylenes from iodotrimethylsilylacetylene and arylcopper(I) 549 (3034)
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– 1-phenyl-1-alkynes from phenylacetylene and trialkylboranes (3 steps) 803 (3252)
– 1-(2-pyridyl)-1-alkynes from 1-alkynes, 2-iodopyridine, and copper 68 (2659)
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– 1,3-diphenylpropyne + lead(IV) acetate 573
- **Compounds containing Two or More Isolated C≡C Triple Bonds**
Synthesis
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Synthesis
- *from Unlike Carbon Skeletons*
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- *involving the C≡C Triple Bond*
– diphenylacetylene + carbon monoxide + nitroarenes + hexadecacarbonylhexacobalt 235 (2812)
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Synthesis
- *from Like Carbon Skeletons*
– 2-butyne 614
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– – from 1-alkynes and trialkylboranes (3 steps) 803 (3252)
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Reactions
- *not involving the C≡C Triple Bond*
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Synthesis
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– – with 4,5-diphenyl-2-oxo-1,3-dioxole 240 (2833)
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Derivatives of the NH_2 Group
- Synthesis
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– *N*-Boc-amino-acids from the amino-acids and *t*-butyl phenyl carbonate 508 (3028)
– *N*-(*o*-hydroxydiphenylmethylene)-amino-acids from the amino-acids and 2-hydroxybenzophenones (+ base) 240 (2832)
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– 2-morpholino-4-oxo-4-phenylbutanoic acids from acetophenones, glyoxylic acid, and morpholine 701 (3224)

Free Amino-Acids
- Synthesis
– – from 2*H*-alkanoic acids and (1.) lithium diisopropylamide, (2.) *O*-alkylhydroxylamines 566 (3100)
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– γ-chloroglutamic acid 46
– γ-fluoroglutamic acid 44

Reactions
– *N*-acyl-3,4-dihydroxyphenyl-L-alanines + iodosobenzene diacetate 562 (3087)

- β-Aminocarboxylic Acids and Derivatives

Derivatives of the COOH Group
- Synthesis
– β-alanine der. from acrylic acid der. and *N*-phenylthiobenzenesulfenamide 228 (2784)

Derivatives of th COOH and NH_2 Groups
- Synthesis
– alkyl 3-arylaminoalkanoates from *N*-arylaldimines, alkyl-2-bromoalkanoates, and zinc 566 (3101)
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– *N*-carboxy-*N*-(2-nitrophenylthio)-β-aminocarboxylic acid anhydrides from *N*-carboxy-β-aminocarboxylic acid anhydrides and 2-nitrobenzenesulfenyl chloride 633 (3146)
– *N,N*-diphenylthio-β-alanine der. from acrylic acid der. and *N*-phenylthiobenzenesulfenamide 228 (2784)

Derivatives fo the NH_2 Group
- Synthesis
– 3-acylamino-3-arylalkanoic acids from alkanoic anhydrides and benzaldehyde *N,N'*-diacylaminals 40
– 3-acylamino-3-arylalkanoic acids from alkanoic anhydrides, benzaldehydes, and nitriles 40

Free Amino-Acids
- Synthesis
– – from 2,4-dioxohexahydropyrimidines by hydrolysis 280
– – from 2,6-dioxotetrahydro-1,3-oxazines by hydrolysis 279
– β-alanine-3-^{11}C 242 (2842)
- Reactions
– β-alanine + carbonyl compounds + isocyanides 345

- Diaminocarboxylic Acids and Derivatives

Derivatives of the NH_2 Groups
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– N^{ϵ}-*t*-butoxycarbonyl-N^{α}-(2-nitrophenylthio)-L-lysine 795

Reactions
– N^{ϵ}-*t*-butoxycarbonyl-L-lysine-copper complex, elimination of copper 795

Free Amino-Acids
-Synthesis
– L-2-amino-4-(*N'*-nitroguanidino)-butanoic acid 370 (2904)
- Reactions
– 2,4-diaminobutanoic acid + *O*-methyl-*N*-nitroisourea + (1.) copper(II) sulfate, (2.) hydrogen sulfide 370 (2904)

Miscellaneous Derivatives
- Synthesis
– N^{α},N^{ω}-bis[1-adamantyloxycarbonyl]-arginine der. from N^{α}-protected arginine and 1-adamantyl carbonochloridate 122 (2708)

● Anilines

- General

Synthesis
– – from nitrobenzenes and dodecacarbonyltriiron 318 (2851)

Reactions
- involving the Amino Group
– – with thiocarbonyl chloride 631 (3132)

- *N*-Carbo-Substituted Anilines

Synthesis
- from Benzene or Benzene Derivatives
– *N*-alkylanilines from benzene and *N*-chloroalkylamines 4
– alkyl-substituted *N*-alkyl-or *N,N*-dialkylanilines from alkylbenzenes and *N*-chloroamines 8
– *N,N*-dialkylanilines from benzene and *N*-chlorodialkylamines 4
– *N,N*-dimethylaniline 3
– nuclear substituted *N,N*-dialkylanilines from activated benzene derivatives and *N*-chlorodialkylamines 5
– *m*-substituted *N*-alkylanilines from *o*-substituted halobenzenes, sodium amide, and alkylamines 58 (2617)
- from Other Anilines
– *N*-acetyl-4-bromoaniline 56 (2609)
– *N*-acetylchloroanilines from acetanilide and titanium(IV) chloride/oxidizing agents 56 (2609)
– *N*-acetyl-4-iodoaniline 56 (2609)

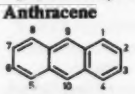
Reactions
- involving the Amino Group
– *N*-alkylanilines + formaldehyde + dialkylamines + acetic acid (trace) 735
- not involving the Amino Group
– acetanilide + *N*-chlorodialkylamines 5
– *N*-alkylanilines + formaldehyde + dialkylamines + acetic acid 735
– *N,N*-dialkylanilines, aminomethylation by Mannich reaction 735

- *N*-Unsubstituted Anilines

Synthesis
- from Benzene or Benzene Derivatives
– – by radical amination with hydroxylamine or hydroxylamine-*O*-sulfonic acid 10
– methoxyanilines by radical amination of methoxybenzenes 12
- from Other Anilines
– 2-amino-α-methylthiophenylacetaldehyde dimethyl acetal 819 (3319)
– chloroanilines from aniline and titanium(IV) chloride/oxidizing agents 56 (2609)
– 2-methylthiomethylanilines from anilines, *t*-butyl hypochlorite, and dimethyl sulfide 685 (3161)

Reactions
- involving the Amino Group
– – with acrylonitrile 698 (3213)
– – with *t*-butyl hypochlorite + methyl 2-oxoalkyl sulfides 816 (3308), 819 (3319)
– – with sodium thiocyanate 435 (2961)
– aminobenzoic acid esters + 2-dimethylaminotetrahydropyran 701 (3225)
– 2,4,6-trimethylaniline + cerium(IV) ammonium nitrate 353
- not involving the Amino Group
– – with (1.) *t*-butyl hypochlorite, (2.) dimethyl sulfide 685 (3161)

● Anthracene



Reactions
- Retention of the Ring Skeletons
– anthracene + cerium(IV) ammonium nitrate 352

● Arenecarbonitriles

- General

Synthesis
– – from aryllithium and pentachlorobenzonitrile 555 (3058)

- Benzonitriles

Synthesis
– – from arylthallium(III) salts and copper(I)- or copper(II) cyanide 232 (2796)
– – from phenyl isocyanides by irradiation 688 (3171)

Reactions
– – with carbonyl chloride/hydrogen chloride 199
– – with *N*-(α-chlorobenzylidene)-carbamoyl halides 200
– – with benzylmalonyl chloride 193, 194

● Arenecarboxamides

- Benzamides

Reactions
– *N*-phenacylbenzamides + hydrogen fluoride 817 (3312)
– 2-hydroxybenzamide + benzoyl chlorides 440 (2982)

● **Arenecarboxylic Acid Chlorides**
- General
Reactions
– – with dialkylcyanamides 202
- Benzoyl Chlorides
Synthesis
– from phenylmercury compounds, carbon monoxide, and palladium chloride 522
Reactions
– – with methyl isocyanoacetate and triethylamine 231 (2792)
– – with methyl 2-isocyanoalkanoates and sodium hydride 231 (2792)
– benzoyl chloride-aluminum chloride complexes + alkynes 116 (2683)

● **Arenecarboxylic Acid Esters**
- General
Synthesis
- from Unlike Carbon Skeletons
– 2-arylethenyl arenecarboxylates from 1,3-diaryl-3-oxopropenes and potassium peroxydisulfate 542
- Benzoic Acid Esters
Synthesis
- from Like Carbon Skeletons
– 2-alkenyl benzoates from alkenes having allylic hydrogen and iodosilver dibenzoate 600
– aryl benzoates from arenes and halosilver dibenzoates 600
- from Unlike Carbon Skeletons
– – from phenylmercury chlorides, carbon monoxide, alcohols, and palladium chloride 522
Reactions
- involving the Ester Group
– phenyl 2-hydroxybenzoates + amidines 563 (3090)

● **Arenecarboxylic Acids**
- General
Synthesis
- from Unlike Carbon Skeletons
– – from arylmercury compounds, carbon monoxide, water, and palladium chloride 522
– – from benzoins or analogs and cerium(IV) ammonium nitrate 348
– – from haloarenes, carbon monoxide, calcium hydroxide, and tetracarbonylnickel 518
Reactions
– – electrochemical reduction 116 (2684)
- Benzoic Acids
Synthesis
- from Like Carbon Skeletons
– 4-benzyloxycarbonylaminobenzoic acid 44
- from Unlike Carbon Skeletons
– – from tetraphenylstannanes, carbon monoxide, water, and palladium chloride 522
Reactions
- involving the Carboxy Group
– 2-aminobenzoic acid + *N*-dichloromethanesulfonamides 323 (2870)
– 2-cyanomethylbenzoic acid + phosphorus(V) chloride 190
– 2-hydroxybenzoic acid + lithium alanate 796

● **Arenedicarboxylic Acid Chlorides**
Reactions
– phthaloyl chloride + tertiary phosphines 322 (2869)

● **Arenes**
see also the individual Arenes
- General
Synthesis
- from Like Ring Skeletons
– – from aminoarenes and lithium alanate 769
– – from methoxyarenes and lithium alanate 796
– – from phenols and lithium alanate 796
– polycyclic arenes from their di- or tetrahydro der., butyllithium, tetramethylethylenediamine, and cadmium chloride 804 (3254)
Reactions
- Retention of the Ring Skeletons
– – with acetic acid + palladium(II) salts (+ oxygen) 595
– – with cerium(IV) ammonium nitrate 206
– – with *N*-chlorodialkylamines 7
– – with lead(IV) acetate 573
- Alkylarenes
Synthesis
- from Like Ring Skeletons
– methylarenes from aromatic aldehydes and lithium/ammonia 227 (2777)
Reactions
- Retention of the Ring Skeleton
– methylbenzenes + acetic acid + oxygen + palladium(II) salts 595
– methylbenzenes + acetic acid + palladium(II) salts 595
– methylbenzenes + cerium(IV) ammonium nitrate 601
– methylbenzenes + chromyl acetate 598

● **Arsine Oxides**
Synthesis
– triphenylarsine oxide 307

● **Arsines**
Synthesis
– optically active tertiary arsines from menthyl arsinothioates and organolithium compounds 693 (3191)
– tetraphenyldiarsine 386
Reactions
– chlorodiphenylarsine, electrochemical reduction 386

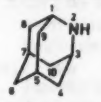
● **Arsine Sulfides**
Reactions
– triphenylarsine sulfide + dimethyl sulfoxide + acid 307

● **Arsinothioic Acid Esters**
Synthesis
– *O*-menthyl methylphenylarsinothioate 693 (3191)

● **Arsoranes**
Reactions
– benylidenetriphenylarsorane + trialkylboranes 649

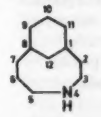
● **Arynes**
Generation
– – from 4,5,12,13-tetrabromo-[2.2]paracyclophane and butyllithium 102
– benzyne from the lithio derivative of 1-(benzotriazol-1-yl)-4-tosyltetrazene 183 (2756)
– benzynes from haloarenes and sodium amide 58 (2617)
Reactions
– benzynes + alkylamines 58 (2617)

● **2-Azaadamantanes**



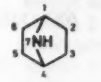
Synthesis
- of the Ring Skeleton
– 4,8-dibromo-2-tosyl der. 699 (3217)

● **4-Azabicyclo[6.3.1]dodecane**



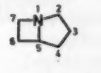
- 4-Azabicyclo[6.3.1]dodeca-1(12),9-dienes
Synthesis
- of the Ring Skeleton
– – from 1-dimethylamino-4-phenylbutane by irradiation 821 (3330)

● **7-Azabicyclo[2.2.1]heptane**



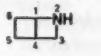
Synthesis
- of the Ring Skeletons
– 1,4-diphenyl-2,3,5,6-tetramethoxycarbonyl der. 473

● **1-Azabicyclo[3.2.0]heptane**



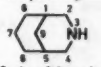
- 1-Azabicyclo[3.2.0]hept-3-enes
Synthesis
- of the Ring Skeletons
– 2,7-dioxo der. from *o*-benzoquinone mono[*O*-sulfonyloximes] 346

● **2-Azabicyclo[2.2.0]hexane**



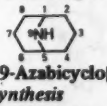
- 2-Azabicyclo[2.2.0]hex-5-enes
Synthesis
- of the Ring Skeleton
– 3-oxo der. from 2-oxo-1,2-dihydropyridines by irradiation 439 (2976)

● **3-Azabicyclo[3.3.1]nonane**



- 3-Azabicyclo[3.3.1]nonanes
Synthesis
- of the Ring Skeletons
– 1-substituted 3-methyl-9-oxo der. from 2-oxocyclohexanecarboxylic acid der., formaldehyde, and methylamine 725
- 3-Azabicyclo[3.3.1]non-6-enes
Synthesis
- of the Ring Skeleton
– 1,5-dinitro der. from 3,5-di-*aci*-nitrocyclohexenes, formaldehyde, and primary amines 733

● **9-Azabicyclo[3.3.1]nonane**



- 9-Azabicyclo[3.3.1]nonanes
Synthesis
- of the Ring Skeletons
– 2,6-dibromo-9-tosyl der. 699 (3217)

- 9-Azabicyclo[3.3.1]nona-2,6-dienes
Synthesis
- from Like Ring Skeletons
– 9-tosyl der. 699 (3217)
Reactions
- Transformation of the Ring Skeleton
– 9-formyl derivative + sulfur dichloride 375 (2927)

● 1-Azabicyclo[2.2.2]octane

- 1-Azoniabicyclo[2.2.2]oct-2-enes
Reactions
- Transformation of the Ring Skeleton
– 3-methoxycarbonyl halides, thermolysis 506 (3022)
- Quinuclidines
Synthesis
- of the Ring Skeleton
– 1-benzyl-4-alkoxycarbonyl-quinuclidinium bromides from alkyl (4-benzyl-4-piperidinylidene)-cyanoacetates (mulistage synthesis) 697 (3210)
- Quinuclidinium Salts
Synthesis
- from Like Ring Skeletons
– 3-acetoxy-1-alkylquinuclidinium bromides from 3-acetoxyquinuclidines and alkyl bromides 221
– 3-acetoxy-1-(2-aryl-2-oxoethyl)-quinuclidinium bromides from 3-acetoxyquinuclidine and aryl 1-bromoalkyl ketones 221

● 6-Azabicyclo[3.2.1]octane

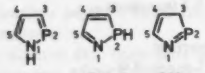
Synthesis
- of the Ring Skeleton
– 5-methoxy-6-methyl derivative 204

● 1-Azabicyclo[4.2.0]octane
- 1-Azabicyclo[4.2.0]octanes
see: Azeto[*a*]pyridine, Hexahydro-

● 1,2-Azaborete

- $N^{\oplus}$, $B^{\ominus}$-Hexahydro-1,2-azaboretes
Synthesis
- of the Ring Skeleton
– – from aziridine and sodium borohydride 659

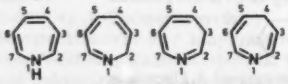
● 1,2-Azaphospholes



1*H*– 2*H*– 3*H*–

- P^{V}-3*H*-1,2-Azaphospholes
Synthesis
- of the Ring Skeleton
– 2,2-dimethyl-P^{V}-3*H*-1,2-azaphospholes from alkenes and alkyl *N*-dimethylphosphinocarboximidates or dialkyl *N*-dimethylphosphinocarbimidates 371 (2910)

● Azepine



2*H*– 3*H*– 4*H*–

- 3*H*-Azepines
Synthesis
- of the Ring Skeleton
– 2,4-dimethoxy-7-phthalimido-3*H*-azepines from 1-phthalimido-1a, 6b-1*H*-azirino[*b*][1]benzofuran and 1,3-dimethoxybenzenes 821 (3329)

● Azete

- Azetidines
Synthesis
- from Like Ring Skeletons
– 1-alkyl-3-benzoyloxy-3-cyanoazetidines from 1-alkyl-3-oxoazetidines, potassium cyanide, and benzoyl chloride 153
– 1-alkyl-3-hydroxyazetidine-3-carboxylic acids from 1-alkyl-3-oxoazetidines 153
– 1-alkyl-3-oxoazetidines from 1-alkyl-3-hydroxyazetidines and chromic acid 153
– 3-carbo-substituted 1-alkyl-3-hydroxyazetidines from 1-alkyl-3-oxoazetidines and organometallic compounds 153
- of the Ring Skeleton
– 4-acyl-4-aminocarbonyl-2-oxoazetidines from 2,3-bis[alkylimino]-oxetanes and 2-haloalkanoic acids 340
– 1-acylamino-3,3-diphenyl-2-oxoazetidines from diphenylketene and *N*-acylhydrazones 331
– 4-alkoxy-2-oxo-1-sulfonylazetidines from 1-alkenyl alkyl ethers and sulfonyl isocyanates 342
– 3-alkyl-2-oxo-1-phenylazetidines from *N*-alkyl-*N*-phenyl-2-alkenamides 341
– 1-alkyl-2-oxo-4-phenylazetidines from 6-phenylcephams and Raney nickel 439 (2977)
– 1-alkyl-2-oxo-4-phenylazetidines from 5-phenylpenams and Raney nickel 439 (2977)
– 1-(1-aminocarbonylalkyl)-2-oxoazetidines from 3-aminoalkanoic acids, aldehydes or ketones, and isocyanides 345
– 4-amino-2-oxo-1-phenylazetidines from enamines and phenyl isocyanate 342
– 1-anilino-2-oxoazetidines from 5-oxo-1-phenylpyrazolidines by irradiation 344
– 1-aryl-2-arylimino-4-oxoazetidines from ketene arylimines and aryl isothiocyanates 693 (3193)
– 1-aryl-4-benzoyl-2-oxoazetidines from *N*-aryl-*N*-phenacylhaloacetamides and base 339
– 1-aryl-4,4-diethoxycarbonyl-2-oxoazetidines from diethyl *N*-haloacetylanilinomalonates and base 339
– 4-aryl-2-oxo-1-phenylazetidines from *N*-phenylarylmethanimines, alkyl 2-bromoalkanoates, and zinc 338
– 3-benzoylamino-2-oxo-1,3,4-triphenylazetidines from 2,4-diphenyl-5-oxo-1,3-oxazolium betaines and *N*-phenylphenylmethanimine 345
– 1-benzyloxy-2-oxoazetidines from 3-bromoalkanoyl chlorides and *O*-benzylhydroxylamine 340
– 3,3-bis[trifluoromethyl]-2,2-difluoro-1,3-diphenylazetidine by cycloaddition 345
– 1-*t*-butyl-3-chloro-2-oxoazetidines from sodium 1-*t*-butylaziridine-2-carboxylates and thionyl- or oxalyl chloride 343
– 3-chloro-1,4-diaryl-2-oxoazetidines from 2-chloroalkanoic acids, phosphoryl chloride, and *N*-arylarylmethanimines 338
– 1-chlorosulfonyl-2-oxoazetidines from alkenes and chlorosulfonyl isocyanate 342
– 3,4-diphenyl-2-oxoazetidines from diphenylcyclopropenone and ammonia or methylamine 343
– 3,4-diphenyl-2-oxoazetidines from 2,3-diphenylpropenamides by irradiation 344
– 4-imino-2-oxoazetidines from carbodiimides and ketenes 332
– 2-oxoazetidine 343
– 2-oxoazetidines from 2*H*-alkanoyl chlorides and imines 330
– 3-oxoazetidines from alkyl 3-aminoalkanoates and alkylmagnesium halides 329
– 2-oxoazetidines from 3-aminoalkanoic acids and ammonia or amines 328
– 2-oxoazetidines from α-diazoketones and imines 330
– 2-oxoazetidines from 1-ethoxy-1-alkynes and imines 330
– 2-oxoazetidines from 3-haloalkanamides and base 340
– 2-oxoazetidines from ketenes and imines 330
– 2-oxopentaphenylazetidine 334
– 2-oxo-1-phenylazetidines from ketene dimethyl acetals and phenyl isocyanate 342
– 2-oxo-1-phenylazetidines from phenyl isocyanates and diazomethane 341
– 2-oxo-3-phenylazetidines from 2-phenylpropanamides and sodium amide 340
– 4-oxo-1,2,3-triphenylazetidines from benzaldehyde phenylnitrones and phenylethynylcopper 694 (3195)
Reactions
- Retention of the Ring Skeleton
– 2,4-dioxoazetidines, *N*-aminomethylation by Mannich reaction 738

● Azeto[2,1-*b*][1,3,4]oxadiazine

2*H*, 6*H*–

- 3,4,7,7a-Tetrahydro-2*H*,6*H*-azeto[2,1-*b*][1,3,4]oxadiazines
Synthesis
- of the Ring Skeleton
– 7a-alkoxy-4-alkoxycarbonyl-3,6-dioxo der. from dialkyl diazenedicarboxylates and ketenes 334

● Azeto[2,1-*b*][1,3]oxazine

2*H*, 6*H*–

- 3,4,7,7a-Tetrahydro-2*H*,6*H*-azeto-[2,1-*b*][1,3]oxazines
Synthesis
- of the Ring Skeleton

– 6-amino-7-oxo der. from 2-substituted 5,6-dihydro-4*H*-1,3-oxazines and aminoacetyl chloride 336

● **Azeto[2,1-*a*]pyrazine**

6*H*–

- **3,4,7,7a-Tetrahydro-6*H*-azeto-[2,1-*a*]pyrazines**

Synthesis

- of the Ring Skeletons

– 1,7-diphenyl-6-oxo der. from 5,6-diphenyl-2,3-dihydropyrazine and ketenes 332

● **Azeto[1,2-*a*]pyridine**

2*H*–

- **Hexahydroazeto[1,2-*a*]pyridines**

Synthesis

- of the Ring Skeleton

– 1-bromo-2-oxo der. 346

– 1-*t*-butoxycarbonyl-2-oxo der. from *t*-butyl 2-diazo-3-oxo-3-piperidinopropanoates by irradiation 65 (2643)

● **Azeto[1,2-*c*][1,3]thiazine**

2*H*,4*H*–

- **Tetrahydroazeto[1,2-*c*][1,3]thiazines**

Synthesis

- of the Ring Skeleton

– 7-azido-6-oxo-2,2,4,4,7a-pentamethyl der. 336

● **Azeto[2,1-*b*][1,3]thiazine**

2*H*,6*H*–

- **Tetrahydroazeto[2,1-*b*][1,3]thiazines**

Synthesis

- of the Ring Skeleton

– 7-amino-7a-aryl-6-oxo der. from 2-aryl-5,6-dihydro-4*H*-1,3-thiazines and phthalimidoacetyl chloride 335

– 6-oxo-7a-phenyl der. from 2-phenyl-5,6-dihydro-4*H*-1,3-thiazine and alkanoyl chlorides 439 (2977)

● **Azeto[2,1-*c*][1,4]thiazine**

- **Hexahydroazeto[2,1-*c*][1,4]thiazines**

Synthesis

- of the Ring Skeleton

– 7-azido-1,1-dimethyl-6-oxo-7a-phenyl der. 336

● **Azido Compounds**

- **General**

Reactions

- without Cyclization

– – with organodichloroboranes 802 (3244)

- **Aliphatic Azido Compounds**

Synthesis

– *vic*-azidonitryloxyalkanes from alkenes, sodium azide, and cerium(IV) ammonium nitrate 354

– azidotriarylcyclopropenes from azidotriarylcyclopropylium bromides and sodium azide 325 (2875)

– di- and polyazidoalkanes from di- or polyalcohols via *O*-sulfonylation and reaction with sodium azide 57 (2612)

Reactions

- Cyclization Reactions

– 2-(1-alkenyl)-3-azido-*p*-benzoquinones, thermal cyclization 816 (3309)

– 1-azidoalkenes + 2-oxoalkylidenetriphenylphosphoranes 817 (3311)

– azidotriarylcyclopropenes, thermal cyclization 325 (2875)

- without Cyclization

– – with trialkylboranes 647

- **Aromatic Azido Compounds**

Synthesis

– 1-amino-2-azido-4-dimethylaminobenzene 299

– 2-azido-1-benzylidenamino-4-dimethylaminobenzenes from benzaldehyde 4-dimethylaminophenylnitrones and hydrazoic acid 299

– 4-azido-*N*,*N*-dimethylaniline 299

Reactions

- Cyclization Reactions

– 2-azido-1-benzylidenamino-4-dimethylaminobenzenes, thermal cyclization 299

- **Heterocyclic Azido Compounds**

Synthesis

– 6-azidopyrido[3,4-*d*]tetrazolo[1,5-*b*]pyridazine 130

– 6-azidopyrido[4,3-*d*]tetrazolo[1,5-*b*]pyridazine 130

– 6-azidotetrazolo[1,5-*b*]-pyridazines from 6-hydrazinotetrazolo[1,5-*b*]pyridazines and nitrous acid 132

Reactions

- Cyclization Reactions

– azido-tetrazolo isomerization of α-azido-*N*-heterocyclic compounds 123

- without Cyclization

– 6-azidotetrazolo[1,5-*b*]pyridazines, photolytic decomposition 135

● **Azine *N*,*N'*-Bis-Oxides**

- **Aldazine N,N'-Bis-oxides**

Structure

– – problems of structural assignment 157

Synthesis

– – from aldoximes and nitrogen dioxide 157

– – from aldoximes and sodium hypobromite 157

Reactions

– – deoxygenation with phosphorus(III) compounds 157

– – thermolysis 157

– – thermolysis in the presence of dipolarophiles 158

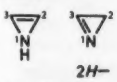
● **Azines**

- **Ketazines**

Synthesis

– – from ketones, ammonia, and diacyl peroxides 117 (2688)

● **Azirine**



2*H*–

- **2*H*-Azirines**

Reactions

- Ring Cleavage Reactions

– – irradiation in methanol 804 (3256)

- **Aziridines**

Synthesis

- from Like Ring Skeletons

– 1-aminoaziridines from 1-phthalimidoaziridines and hydrazine 438 (2975)

– 1-dialkylaminomethylaziridines from 1-hydroxymethylaziridines and dialkylamines 497 (2985)

- of the Ring Skeleton

– 1-aminoaziridines from *vic*-dimesyloxyalkanes and hydrazine 438 (1974)

– 2,3-diphenylaziridines from tetrazolo[1,5-*a*]pyrimidines and *trans*-stilbene 135

– 1-phthalimidoaziridines from alkenes, *N*-aminophthalimide, and lead(IV) acetate 438 (2975)

Reactions

- Ring Cleavage Reactions

– 1,3-diaryl-2,2-dichloroaziridines + dialkylamines 180 (2739)

- Transformation of the Ring Skeleton

– 2,3-dimethoxycarbonyl-1-(4-methoxyphenyl)-aziridine + dimethyl acetylenedicarboxylate 470

– sodium 1-*t*-butylaziridine-2-carboxylates + oxalyl chloride 343

– sodium 1-*t*-butylaziridine-2-carboxylates + thionyl chloride 343

– 1-tosylaziridine + alkyl cyanoacetates + base 546

● **Azo Compounds**

see: Diazenes

● **Azomethine Imines**

Synthesis

– *N*-(4-chlorophenyl)-*N*-(cyanoimino)-fluorene-9-iminium ylid 471

– 1-ethoxycarbonyliminopyridinium ylid 470

– 2-imino-3,4-dihydroisoquinolinium ylid 471

– 1-phenyliminoquinolinium ylid 471

Reactions

– – 1,3-cycloaddition reactions 472

● **Azomethine Ylids**

Synthesis

– 1-methylimidazolium 3-dicyanomethylide 470

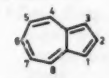
– pyridinium cyclopentadienides from pyridines and diazocyclopentadienes 498 (2989)

– pyridinium phenacyclide 469

Reactions

– – 1,3-cycloaddition reactions 472

● **Azulene**



Synthesis

- from Like Ring Skeletons

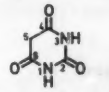
– 1-(2-hydroxyethyl)-azulenes from azulenes and oxirane 626 (3111)

- of the Ring Skeleton

– 2-aminoazulenes from 2-oxo-2*H*-cyclohepta[*b*]furans and cyanoacetamide 55 (2605)

– 2-aminoazulenes from 2-oxo-2*H*-cyclohepta[*b*]furans and malodinitrile 55 (2605)

● **Barbituric Acids**

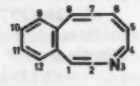


Synthesis

– 1,3-disubstituted 5-ethoxycarbonylbarbituric acid

from diethyl malonate and isocyanates 564 (3094)

● **3-Benzazecine**



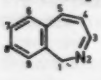
- **1,2,3,4,5,6,7,8-Octahydo-3-benzazecines**

Synthesis

- of the Ring Skeleton

– – from 1,3,4,6,7,11b-hexahydro-2*H*-benzo[*a*]quinolizine by *N*-oxidation-reductive cleavage 543

● **2-Benzazepine**



1*H*–

- **2,3-Dihydro-1*H*-2-benzazepines**

Synthesis

- from Like Ring Skeletons

– 1-oxo-5-phenyl der. from 5-hydroxy-1-oxo-5-phenyl-2,3,4,5-tetrahydro-1*H*-2-benzazepines 507 (3025)

- **2,3,4,5-Tetrahydro-1*H*-2-benzazepines**

Synthesis

- of the Ring Skeleton

– 4-hydroxy-1-oxo-5-phenyl der. from 1-(2-aminoethyl)-1-phenyl-1,3-dihydro-2-benzofurans, thermally 507 (3025)

● **Benzazete**

Synthesis

- of the Ring Skeleton

– 2-arylbenzazetes from 4-aryl-1,2,3-benzotriazines, thermally 694 (3196)

Reactions

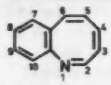
- Fusion of New Rings

– 2-phenylbenzazetes + 1,3-diphenyl-2-benzofuran 694 (3196)

Transformation of the Ring Skeleton

– 2-phenylbenzazete + tetraphenyl-cyclopentadienone 694 (3196)

● **1-Benzazocine**

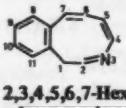


Synthesis

- Of the Ring Skeleton

– 2,3,4,5-tetraphenyl der. 694 (3196)

● **3-Benzazonine**



- **2,3,4,5,6,7-Hexahydro-1*H*-3-benzazonines**

Synthesis

- of the Ring Skeleton

– – from 1,2,3,5,6,10b-hexahydro-pyrrolo[2,1-*a*]quinoline by *N*-oxidation-reductive cleavage 543

● **Benzenes**

- **General**

Reactions

- Retention of the Ring Skeleton

– alkylbenzenes + cerium(IV) ammonium nitrate 351

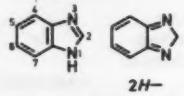
- **Benzene Hydrocarbons**

Synthesis

- from Like Ring Skeletons

– methylbenzenes from benzaldehydes and lithium/ammonia 227 (2777)

● **Benzimidazole**



2*H*–

- **Benzimidazoles**

Synthesis

- from Like Ring Skeletons

– 1-ethenylbenzimidazole 439 (2979)

- of the Ring Skeleton

– 1-alkylamino der. from *N,N*-dialkyl-*N'*-(2-nitrophenyl)-hydrazines, thermally 694 (3197)

– 2-alkyl-1-hydroxybenzimidazole 3-oxides from benzofuroxan and 1-nitroalkanes 374 (2920)

– 2-aryl-5(6)-dimethylamino-benzimidazoles from 2-azido-1-arylmethylenamino-4-dimethylaminobenzenes, thermally 299

– 1-cyanobenzimidazole 136

– 1-hydroxybenzimidazole 3-oxides from benzofuroxan and 1-nitroalkanes 560 (3078)

Reactions

- Retention of the Ring Skeleton

– – *N*-aminomethylation by Mannich reaction 739

- **2*H*-Benzimidazoles**

Synthesis

- of the Ring Skeleton

– 2,2-dialkyl-2*H*-benzoimidazole 1,3-bis-oxides from benzofuroxan and *sec*-nitroalkanes 374 (2920)

- **2,3-Dihydrobenzimidazoles**

Synthesis

- of the Ring Skeleton

– 1,3-dihydroxy-2-oxo der., from benzofuroxans and formaldehyde 374 (2924)

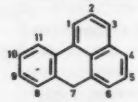
– 1-hydroxy-2-oxo der. from 2-nitroanilinoacetonitriles and base 695 (3202)

Reactions

- Retention of the Ring Skeleton

– 2-thiono der., *N*-aminomethylation by Mannich reaction 739

● **Benzo[*de*]anthracene**



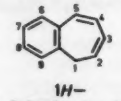
7*H*–

Synthesis

- of the Ring Skeleton

– 7-oxo-1,8,11-trimethoxy der. from methoxycarbonyl-*p*-benzoquinones and 2-methoxy-naphthalene (several steps) 319 (2855)

● **Benzocycloheptene**



1*H*–

- **2,3-Dihydro-1*H*-benzocycloheptenes**

Synthesis

- of the Ring Skeleton

– – from 1-allyl-2-ethenylbenzene and sodium/diisopropylamine 149

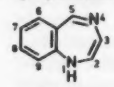
- **2,3,4,5-Tetrahydro-1*H*-benzocycloheptenes**

Synthesis

- of the Ring Skeleton

– – from 1-allyl-2-ethenylbenzene and sodium/diisopropylamine 149

● **1,4-Benzodiazepine**



1*H*–

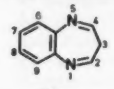
- **2,3-Dihydro-1*H*-1,4-benzodiazepines**

Reactions

- Fusion of New Rings

– 5-phenyl derivatives + nitrile oxides *in situ* 559 (3075)

● **1,5-Benzodiazepine**



3*H*–

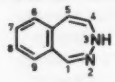
- **3*H*-1,5-Benzodiazepines**

Synthesis

- of the Ring Skeleton

– 2-(2-hydroxyphenyl)-4-phenyl der. 148

● **2,3-Benzodiazepine**



3*H*–

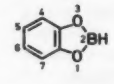
- **4,5-Dihydro-3*H*-2,3-Benzodiazepines**

Synthesis

- of the Ring Skeleton

– 3-phenyl der. from 2-phenyl-3,4-dihydroisoquinolinium bromide and *O*-mesitylsulfonylhydroxylamine 159

● **1,3,2-Benzodioxaborole**



Synthesis

- from Like Ring Skeletons

– 2-(1-alkenyl)-1,3,2-benzodioxaboroles from 1,3,2-benzodioxaborole and alkynes 437 (2970)

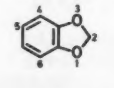
Reactions

- Ring-Cleavage Reactions

– 2-(1-alkenyl) der., deuterolysis 437 (2970)

– 2-(1-alkenyl) der. + water 437 (2970)

● **1,3-Benodioxole**



- **1,3-Benzodioxoles**

Synthesis

- of the Ring Skeleton

– 2-alkoxy-2-alkoxymethyl der. from catechol and dialkyl acetylenedicarboxylates 374 (2922)

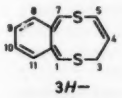
- **Hexahydro-1,3-benzodioxoles**

Synthesis

- of the Ring Skeleton

– – from 1,2-dihydroxycyclohexane, dimethyl sulfoxide, and *N*-halosuccinimides 802 (3245)

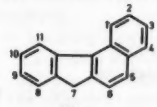
● **2,6-Benzodithionin**



3*H*–

- 1,4,5,7-Tetrahydro-3*H*-2,6-benzodithionins
Synthesis
- of the Ring Skeleton
– – from 1,2-bis[bromomethyl]-benzene and dilithio-1,3-bis-[1,3-dithian-2-yl]-benzene 92

● **Benzo[*c*]fluorene**



7*H*–

Synthesis
- of the Ring Skeleton
– 6-carboxy-7-oxo-5-phenyl der. from 1,4-diphenylnaphthalene-2,3-dicarboxylic anhydrides 118 (2694)

● **1-Benzofuran**

- 2,3-Dihydro-1-benzofurans
Synthesis
- of the Ring Skeleton
– 2-phenyl derivatives from 3-(2-hydroxyphenyl)-3-phenyl-propenes, thermally 503 (3008)
Reactions
- Retention of the Ring Skeleton
– – aminomethylation by Mannich reaction 728

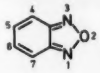
- 3a,4,5,6,7,7a-Hexahydro-1-benzofurans
Synthesis
- of the Ring Skeleton
– 7-oxo der. from 2-ethylmethyl-sulfonio-3-oxocyclohexene methyl-sulfate and β-dicarbonyl compounds 560 (3080)

- Octahydro-1-benzofurans
Synthesis
- of the Ring Skeleton
– 2-cyclohexylimino der. from 3-cyano-2-cyclohexyloctahydro-1,2-benzoxazines and base 503 (3007)

● **2-Benzofuran**

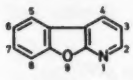
- 1,3-Dihydro-2-benofurans (Phthalans)
Synthesis
- of the Ring Skeleton
– *trans*-bi-phthalidylidene 322 (2869)
Reactions
- Retention of the Ring Skeleton
– 3,3-dichlorophthalide + tertiary phosphines 322 (2869)
- Ring-Cleavage Reactions
– 3-arylmethylphthalides + lithium alanate 548 (3031)
- Transformation of the Ring Skeleton
– 1-(2-aminoethyl)-1-phenyl der., thermal rearrangement 507 (3025)

● **Benzofurazan**



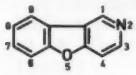
- Benzofurazan *N*-Oxides (Benzofuroxans)
Reactions
- Transformation of the Ring Skeleton
– – with disodium cyanamide 367 (2890)
– – with formaldehyde 374 (2924)
– – with nitroalkanes + ammonia or amines 374 (2920), 560 (3078)
– – with phenols 186 (2767)

● **[1]Benzofuro[2,3-*b*]pyridine**



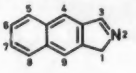
Synthesis
- of the Ring Skeleton
– 2,3,4-trichloro derivative 372 (2915)

● **[1]Benzofuro[3,2-*c*]pyridine**



Synthesis
- of the Ring Skeleton
– 1,3,4-trichloro derivative 372 (2915)

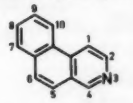
● **Benzo[*f*]isoindole**



- 2,3-Dihydro-1*H*-benzo[*f*]isoindoles
Synthesis
- of the Ring Skeleton
– 1,3-dioxo-2-phenyl der. from 1,2-bis[bromomethylene]-cyclohexadienes and *N*-phenylmaleimide 416

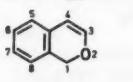
- 2,3,3a,4,9,9a-Hexahydro-1*H*-benzo[*f*]isoindoles
Synthesis
- of the Ring Skeleton
– 1,3-dioxo-2-phenyl der. from 1,2-bis[methylene]-cyclohexadienes and *N*-phenylmaleimide 416

● **Benzo[*f*]isoquinoline**



Synthesis
- of the Ring Skeleton
– 1,3-dichloro derivative 197

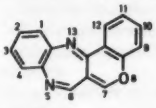
● **2-Benzopyran**



1*H*–

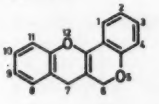
- Isochromans
Synthesis
- from Like Ring Skeletons
– 1-alkylthiothiocarbonyl-1-cyano-isochromans from 1-cyanoiso-chroman, phenyllithium, carbon disulfide, and alkyl iodides 297
– 1-aminothiocarbonyl-1-cyano-isochromans from 1-cyanoiso-chromans and isothiocyanates 297
– 1-cyano-1-phenylthiothiocar-bonylisochroman 297
- of the Ring Skeleton
– 3-oxoisochroman 107
Reactions
- Retention of the Ring Skeleton
– 1-cyanoisochromans + (1.) potassium *t*-butoxide, (2.) organic isothiocyanates 297
- Transformation of the Ring Skeleton
– 3-oxoisochroman, thermolysis 107

● **[1]Benzopyrano[4,3-*b*]-1,5-benzodiazepine**



Synthesis
- of the Ring Skeleton
– – from 3-(1-dimethylamino-alkylidene)-2-(2-hydroxyphenyl)-3*H*-1,5-benzodiazepines, thermally on ion-exchange resin 148

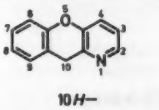
● **[1]Benzopyrano[4,3-*b*][1]benzo-pyran**



6*H*,7*H*–

Synthesis
- of the Ring Skeleton
– 6-oxo der. from 4-hydroxy-3-(2-hydroxybenzyl)-coumarins and phosphoryl chloride 754

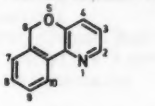
● **[1]Benzopyrano[3,2-*b*]pyridine**



10*H*–

5a,6,7,8,9,9a-Hexahydro-10*H*-[1]benzopyrano[3,2-*b*]pyridines
Synthesis
- of the Ring Skeleton
– 5a-amino der. from 2-amino-methyl-3-hydroxypyridines and 1-aminocyclohexenes 770

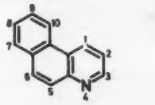
● **[2]Benzopyrano[4,3-*b*]pyridine**



6*H*–

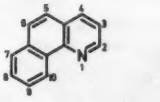
Synthesis
- of the Ring Skeleton
– 6-oxo der. from 2-diazonio-benzoate and 3-hydroxypyri-dines 375 (2929)

● **Benzo[*f*]quinoline**



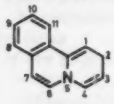
Synthesis
- of the Ring Skeleton
– – from 2-(2-naphthylamino)-ethyl ketones and acid 767
– – from *N*-(2-napththyl)-2-propenimines, thermally 69 (2661)

● **Benzo[*h*]quinoline**



Synthesis
- of the Ring Skeleton
– – from 2-(1-napthtyl-amino)-ethyl ketones and acid 767
– – from *N*-(1-naphthyl)-2-propenimines, thermally 69 (2661)

● **Benzo[*a*]quinolizine**



2*H*–

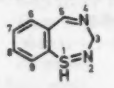
- 1,3,4,6,7,11b-Hexahydro-2*H*-benzo[*a*]quinolizines
Reactions
- Ring-Cleavage Reactions
– – by *N*-oxidation -reductive cleavage 543

● **1,3-Benzoselenazine**

4*H*–

Synthesis
- of the Ring Skeleton
– 2-chloro-4-oxo derivative 192

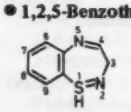
● **1,2,4-Benzothiadiazepine**



S^{IV}–3*H*–

- 4,5-Dihydro-S^{IV}-3*H*-1,2,4-benzothiadiazepines
Synthesis
- of the Ring Skeleton
– 1-substituted 3-oxo 1-oxides from 2-methoxycarbonylmethylphenyl sulfoxides and hydrazoic acid 186 (2770)

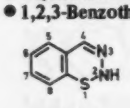
● **1,2,5-Benzothiadiazepine**



S^{IV}–3*H*–

- 4,5-Dihydro-S^{IV}-3*H*-1,2,5-benzothiadiazepines
Synthesis
- of the Ring Skeleton
– 4-oxo-1-phenyl 1-oxides from 3-chloromethyl-1-phenyl-S^{IV}-1,2,4-benzothiadiazine 1-oxides and sodium hydroxide 69 (2663)

● **1,2,3-Benzothiadiazine**



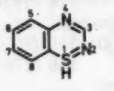
2*H*–

- 2*H*-1,2,3-Benzothiadiazines
Synthesis
- of the Ring Skeleton
– 1,1-dioxide 67 (2654)

- 5,6,7,8-Tetrahydro-2*H*-1,2,3-benzothiadiazines
Synthesis
- of the Ring Skeleton
– 2-aryl der. from 1-aryl-hydrazonomethyl-2-thiocyanato-cyclohexenes and perchloric acid 225

- 5,6,7,8-Hexahydro-1,2,3-benzothiadiazinium Salts
Synthesis
- of the Ring Skeleton
– 2,2-dimethyl, perchlorate 225

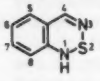
● **1,2,4-Benzothiadiazine**



S^{IV}–

Synthesis
- of the Ring Skeleton
– 3-chloromethyl-1-phenyl-S^{IV}-1,2,4-benzothiadiazine 1-oxides from 2-chloroacetylaminodiphenyl sulfoxide and sodium azide 69 (2663)

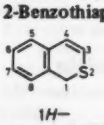
● **2,1,3-Benzothiadiazine**



1*H*–

- 5,6,7,8-Tetrahydro-1*H*-2,1,3-benzothiadiazines
Synthesis
- of the Ring Skeleton
– 2,2-dioxides, from 2-acylcyclo-hexanones and sulfamide 260

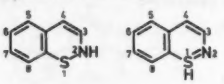
● **2-Benzothiapyran**



1*H*–

- 3,4-Dihydro-1*H*-2-benzothiapyrans
Synthesis
- from Like Ring Skeletons
– 1-alkylthiothiocarbonyl-1-cyano der. from 1-cyano der., phenyl-lithium, carbon disulfide, and alkyl iodides 297
– 1-aminothiocarbonyl-1-cyano der. from 1-cyano der. and isothiocyanates 297
– 1-cyano-1-phenylthiothio-carbonyl der. 297
Reactions
- Retention of the Ring Skeleton
– 1-cyano der. + (1.) potassium *t*-butoxide, (2.) organic isothiocyanates 297

● **1,2-Benzothiazine**

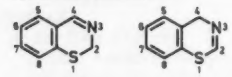


2*H*– S^{IV}–

- 3,4-Dihydro-2*H*-1,2-benzothiazines
Synthesis
- of the Ring Skeleton
– 2-substituted 4-oxo der. from 2-diazoacetylbenzenesulfonamides and acid 506 (3019)

- 3,4-Dihydro-S^{IV}-1,2-benzothiazines
Synthesis
- of the Ring Skeleton
– 1-substituted 3-oxo 1-oxides from 2-methoxycarbonylmethylphenyl sulfoxides and hydrazoic acid 186 (2770)

● **1,3-Benzothiazine**



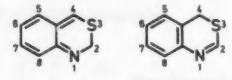
2*H*– 4*H*–

- 4*H*-1,3-Benzothiazines
Synthesis
- of the Ring Skeleton
– 2-chloro-4-oxo der. from 2-thiocyanatobenzoic acids and phosphorus(V) chloride 191

- 3,4-Dihydro-2*H*-1,3-benzothiazines
Synthesis
- of the Ring Skeleton
– – from 2-aminomethyl-benzenethiols and aldehydes or ketones 238 (2823)

- 3,4,5,6,7,8-Hexahydro-2*H*-1,3-benzothiazines
Synthesis
- of the Ring Skeleton
– 2-imino-3,4,5,6,7,8-hexahydro-2*H*-1,3-benzothiazine(4-spiro)cyclohexane 281

● **3,1-Benzothiazine**

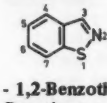


2*H*– 4*H*–

- 1,2-Dihydro-4*H*-3,1-benzothiazines
Reactions
- Transformation of the Ring Skeleton
– 2,4-dithiono der. + 1,2-diaminoethane 506 (3020)

- 1,4,5,6,7,8-Hexahydro-2*H*-3,1-benzothiazines
Synthesis
- of the Ring Skeleton
– 2-imino-1,4,5,6,7,8-hexahydro-2*H*-3,1-benzothiazine-(4-spiro)cyclohexanes from cyclohexanone and thioureas 282

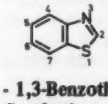
● **1,2-Benzothiazole**



- 1,2-Benzothiazolium Salts
Reactions
- Transformation of the Ring Skeleton
– 3-chloro-1,2-benzothiazolium chlorides + methyl ketones + pyridine 559 (3076)

- 2,3-Dihydro-1,2-benzothiazoles
Reactions
- Retention of the Ring Skeleton
– saccharin, *N*-aminomethylation by Mannich reaction 740

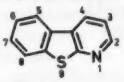
● **1,3-Benzothiazole**



- 1,3-Benzothiazoles
Synthesis
- from Like Ring Skeletons
– 2-acyl der. from 1,3-benzothiazoles, aldehydes, iron(II) sulfate, and *t*-butyl hydroperoxide 15
– 2-aminocarbonyl der. 19
– 2-(1,4-dioxanyl) der. 16
-of the Ring Skeleton
– 2-alkoxycarbonyl 3-oxides from *o*-chloronitrobenzenes

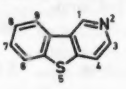
and alkyl mercaptoacetates 696 (3204)
– 2-amino-6-methyl der. 232 (2798)
– 2-sulfonylamino der. from 2-aminobenzenethiol and *N*-dichloromethylene-sulfonamides 323 (2870)
Reactions
- *Fusion of New Rings*
– 2-chloro-1,3-benzothiazole + ammonium azide 84
- *Retention of the Ring Skeleton*
– – aminomethylation by Mannich reaction 728
– – radical *C*-acylation 15
- 2,3-Dihydro-1,3-benzothiazoles
Synthesis
- *of the Ring Skeleton*
– 2,2-dialkyl der. from 2-aminobenzenethiol, primary or secondary alcohols, and cyclohexene (+ irradiation) 235 (2808)

● [1]Benzothieno[2,3-*b*]pyridine



Synthesis
- *of the Ring Skeleton*
– 2,3,4-trichloro derivative 372 (2915)

● [1]Benzothieno[3,2-*c*]pyridine



Synthesis
- *of the Ring Skeleton*
– 1,3,4-trichloro derivative 372 (2915)

● 1-Benzothiophene

Synthesis
- *of the Ring Skeleton*
– – from 2-acylthiophenes and 2-(1,3-dioxolan-2-yl)-ethyl-magnesium bromides 818 (3314)
– 2-acyl-3-amino der. from 3-chloro-1,2-benzothiazolium chlorides and methyl ketones 559 (3076)

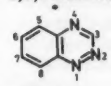
● 2-Benzothiophene

Synthesis
- *of the Ring Skeleton*
– 2-alkoxycarbonyl-3-amino der. from 2-nitrobenzonitriles and alkyl mercaptoacetates 815 (3304), 818 (3318)

● 1,2,3-Benzotriazine

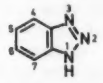
- 1,2,3-Benzotriazines
Reactions
-Transformation of the Ring Skeleton
– 4-azido der., irradiation 136
- 3,4-Dihydro-1,2,3-benzotriazines
Synthesis
- *of the Ring Skeleton*
– 3-alkyl-4-oxo der. from 1-alkyl-3-(2-ethoxycarbonylphenyl)-triazenes, thermally 237 (2822)
– 3-alkyl-4-oxo der. from 2-ethoxycarbonylphenyldiazonium salts and alkylamines 237 (2822)

● 1,2,4-Benzotriazine



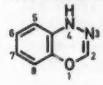
Synthesis
- *of the Ring Skeleton*
– 3-amino-1,2,4-benzotriazine 1,4-bis-oxide 367 (2890)

● Benzotriazole



- Benzotriazoles
Reactions
- *Retention of the Ring Skeleton*
– – *N*-aminomethylation by Mannich reaction 739
- 3a,4,5,6,7,7a-Hexahydrobenzotriazoles
Synthesis
- *of the Ring Skeleton*
– 1-heteroaryl-7a-morpholino der. from tetrazoloazines and 1-morpholinocyclohexene 134

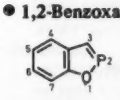
● 1,3,4-Benzoxadiazine



4*H*–

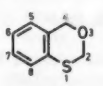
Synthesis
- *of the Ring Skeleton*
– – from *N,N'*-diacyl-*N*-(2-halophenyl)-hydrazines and base 564 (3092)

● 1,2-Benzoxaphosphole



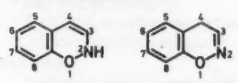
- 2,3-Dihydro-1,2-benzoxaphospholes
Synthesis
- *of the Ring Skeleton*
– 2-alkoxy 2-oxides from 2-aminomethylphenols and trialkyl phosphites 739

● 3,1-Benzoxathian



Synthesis
- *of the Ring Skeleton*
– 4-oxo der. from alkyl 2-carboxyphenyl sulfoxides and acetic anhydride 507 (3024)

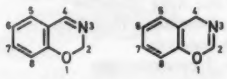
● 1,2-Benzoxazine



2*H*– 4*H*–

- 4a,5,6,7,8,8a-Hexahydro-4*H*-1,2-benzoxazinium Salts
Synthesis
- *of the Ring Skeleton*
– 2-cyclohexyl der. tetrafluoroborates from cyclohexenes and α-chloroaldehyde *N*-cyclohexylnitrones 500 (2997)
- Octahydro-1,2-benzoxazines
Synthesis
- *of the Ring Skeleton*
– 3-cyano-2-cyclohexyl der. from α-chloro-aldehyde *N*-cyclohxylnitrones and alkenes 503 (3007)
– 3-cyano-2-cyclohexyl der. from cyclohexenes, α-chloro-aldehyde cyclohexylnitrones silver tetrafluoroborate, and potassium cyanide 550 (3038)
Reactions
- *Transformation of the Ring Skeleton*
– 3-cyano-2-cyclohexyl der. + potassium *t*-butoxide 503 (3007)

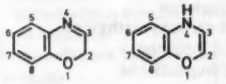
● 1,3-Benzoxazine



2*H*– 4*H*–

- 4*H*-1,3-Benzoxazines
Synthesis
- *of the Ring Skeleton*
– 4-oxo-2-phenyl der. from 2-hydroxybenzamide and benzoyl chlorides 440 (2982)
Reactions
- *Transformation of the Ring Skeleton*
– 4-oxo-2-phenoxy der. + *O*-alkyl-isoureas + base 562 (3088)
– 4-oxo-2-phenoxy der. + *S*-alkyl-isothioureas + base 562 (3088)
– 4-oxo-2-phenoxy der. + amidines + base 562 (3088)
– 4-oxo-2-phenoxy der. + *N,N*-dialkylguanidines + base 562 (3088)
– 4-oxo-2-phenyl der. + amidines + base 506 (3018)
- 3,4-Dihydro-2*H*-1,3-benzoxazines
Synthesis
- *of the Ring Skeleton*
– – from 2-aminomethylphenols and aldimines 770
– 4-oxo-2-thiono der. from *O*-(2-methoxycarbonylphenyl)-thiocarbamates and acid 325 (2878)
Reactions
- *Ring-Cleavage Reactions*
– 3-alkyl der. + phenols 721

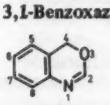
● 1,4-Benzoxazine



2*H*– 4*H*–

- 2*H*-1,4-Benzoxazines
Synthesis
- *of the Ring Skeleton*
– 3-amino-2*H*-1,4-benzoxazine 68 (2657)
- 4*H*-1,4-Benzoxazines
Synthesis
- *of the Ring Skeleton*
– 3-amino-4*H*-1,4-benzo-oxazine 68 (2657)

● 3,1-Benzoxazine

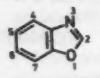


4*H*–

Synthesis
- *of the Ring Skeleton*
– 4-oxo-2-sulfonylamino der. from 2-aminobenzoic acid and *N*-dichloro-methylenesulfonamides 323 (2870)
Reactions
- *Transformation of the Ring Skeleton*

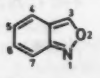
– 4-oxo der. + 1-diethylamino-1-alkynes 237 (2819)

● 1,3-Benzoxazole



- 1,3-Benzoxazoles
Synthesis
- *of the Ring Skeleton*
– 2-sulfonylamino-1,3-benzoxazoles from 2-aminophenol and *N*-dichloromethylenesulfonamides 323 (2870)
- 2,3-Dihydro-1,3-benzoxazoles
Reactions
- *Retention of the Ring Skeleton*
– 2-oxo der., *N*-aminomethylation by Mannich reaction 739
- 2,6-Dihydro-1,3-benzoxazoles
Synthesis
- *of the Ring Skeleton*
– 6-oxo-4,5,7-triphenyl der. from 4-amino-1,3-dihydroxy-2,5,6-triphenylbenzene and ketones 502 (3006)

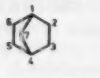
● 2,1-Benzoxazole



- 2,1-Benzoxazolium Salts
Reactions
- *Ring-Cleavage Reactions*
– – with triethylamine 345

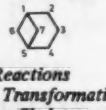
● Berbines
see: Dibenzo[*a,g*]quinolizine, 5,6,13,13a-Tetrahydro-8*H*-

● Bicyclo[2.2.1]heptane



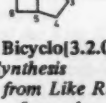
- Bicyclo[2.2.1]heptanes (Norbornanes)
Reactions
- *Transformation of the Ring Skeleton*
– 2-chloroborane + silver nitrate/dimethyl sulfoxide 367 (2888)
- Bicyclo[2.2.1]heptenes
Synthesis
- *of the Ring Skeleton*
– 5-carboxy-4-carboxymethylene-bicyclo[2.2.1]heptene 34
- Bicyclo[2.2.1]heptadienes (Norbornadienes)
Reactions
- *Transformation of the Ring Skeleton*
– – with palladium chloride, carbon monoxide, and methanol 521

● Bicyclo[3.1.1]heptane



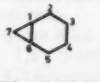
Reactions
- *Transformation of the Ring Skeleton*
– 3-hydroxy-3-tosyloxy der., detosyloxylation-rearrangement 116 (2686)

● Bicyclo[3.2.0]heptane



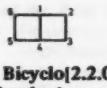
- Bicyclo[3.2.0]hept-2-enes
Synthesis
- *from Like Ring Skeletons*
– 6-oxo der. 408
- *of the Ring Skeleton*
– 7,7-dichloro-6-oxo der. 408

● Bicyclo[4.1.0]heptane



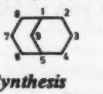
- Bicyclo[4.1.0]hept-3-enes
Synthesis
- *of the Ring Skeleton*
– 7,7-dialkoxycarbonyl der. from 1,4-cyclohexadienes and dialkoxycarbonylcarbenes 138

● Bicyclo[2.2.0]hexane



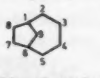
- Bicyclo[2.2.0]hex-2-enes
Synthesis
- *of the Ring Skeleton*
– 5,6-dimethoxycarbonyl der. 354
- Bicyclo[2.2.0]hexa-2,5-dienes
Reactions
- *Transformation of the Ring Skeleton*
– 2-alkoxycarbonyl-3-phenyl der. + 2,4-diphenyl-3-methyl-5-oxy-1,3-oxazolium betaine 376 (2932)

● Bicyclo[3.3.1]nonane



Synthesis
- *of the Ring Skeleton*
– 9-oxo der. from 1,5-cyclooctadiene via hydroboration 776

● Bicyclo[4.2.1]nonane

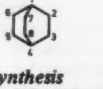


- Bicyclo[4.2.1]non-3-enes
Synthesis
- *of the Ring Skeleton*
– – from bicyclo[3.2.1]oct-2-enes and dichlorocarbene (2 steps) 800 (3238)

● Bicyclo[6.1.0]nonane

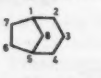
- Bicyclo[6.1.0]nonanes
Synthesis
- *of the Ring Skeleton*
– 9,9-dibromobicyclo[6.1.0]nonane 32
- Bicyclo[6.1.0]non-4-enes
Reactions
- *Transformation of the Ring Skeleton*
– bicyclo[6.1.0]non-4-ene + dibenzonitrile-palladium(II) chloride 366 (2885)

● Bicyclo[2.2.2]octane



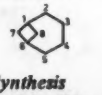
Synthesis
- *of the Ring Skeleton*
– 2,6-dioxo der. 231 (2794)

● Bicyclo[3.2.1]octane



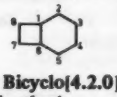
- Bicyclo[3.2.1]oct-2-enes
Synthesis
- *of the Ring Skeleton*
– 2-acetoxy-4,4-dimethyl-bicyclo[3.2.1]oct-2-ene 570

● Bicyclo[4.1.1]octane



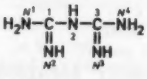
Synthesis
- *of the Ring Skeleton*
– 7,7-dimethyl-3-oxo der. 116 (2686)

● Bicyclo[4.2.0]octane



- Bicyclo[4.2.0]oct-1(6)-enes
Synthesis
- *from Like Ring Skeletons*
– 3,4-dibromo-7,9-dioxo der. 212

● Biguanides



Synthesis
– N^1-aryl-N^4-(3-oxobutanoyl)-biguanides from N^1-arylbiguanides and diketene 536
Reactions
- *Cyclization Reactions*
– N^1-arylbiguanides + diketene 536
– N^1-phenylbiguanides + 2-oxo-1,3-dioxolane 666
– N^1-phenylbiguanides + 2-thiono-1,3-dithiolane 666
- *without Cyclization*
– N^1-arylbiguanides + diketene 536

● Biphenyls
- General
Synthesis
– – from dichlorodiphenyltelluranes and Raney nickel/bis[2-methoxyethyl]ether 174 (2714)
– unsymmetrical biphenyls from *N*-(3-hydroxyphenyl)-arenesulfonamides and potassium hydroxide 175 (2715)
- Functional Biphenyl Derivatives
Synthesis
– dialkylaminobiphenyls from biphenyls and *N*-chlorodialkylamines 7
– *N,N,N',N'*-tetramethylbenzidine 7

● Boranates
Reactions
– potassium cyanotriethylboranate + acyl chlorides 652
– sodium 1-propynyltrialkylboranates + chlorotrimethylsilane 309
– sodium triethylboranate + methyltriphenylphosphonium bromide 649

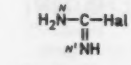
● Boranes
- General
Reactions
– – rearrangement reactions, survey 635
– tertiary boranes + methylenetrimethylaminium ylids 648
– tertiary boranes + trimethylamine oxide 650
- 1-Alkenylboranes and Substitution Products
Synthesis
– 1-alkyl-2-trimethylsiyl-1-propenyldialkylboranes from sodium 1-propynyltrialkylboranates and chlorotrimethylsilane 309
Reactions
– 1-alkenyldialkylboranes + cyanogen bromide 429 (2935)
– 3-chloro-1-propenyldialkylboranes + methyllithium 672

– 3-diethylboryl-2-trimethylsilyl-2-pentene + acetic acid 310
– 3-diethylboryl-2-trimethylsilyl-2-pentene + acetylacetone 310
– 3-diethylboryl-2-trimethylsilyl-2-pentene + methanol 310
– 3-diethylboryl-2-trimethylsilylpentene + (1.) triethylaluminum, (2.) water 310
- 2-Alkenylboranes and Substitution Products
Reactions
– triallylborane + *p*-benzoquinone 659
– triallylborane + nitriles 659
- Alkylboranes Type RBX_2
Synthesis
– *t*-alkyl-(anilino)-phenylthioboranes from trialkylboranes, phenyl isocyanide, and benzenethiol (2 steps) 641
Reactions
– alkyldichloroboranes + azido compounds 802 (3244)
- Arylboranes and Substitution Products
Reactions
– aryldichloroboranes + azido compounds 802 (3244)
– diamino-phenylboranes + methyl benzenesulfenate 555 (3059)
- Dialkylboranes Type R_2BH
Reactions
– – with alkynes 429 (2935)
– – with 1-bromo-1-alkynes 644
– – with 2-dimethylaminomethylcyclopentanone 751
- Dialkylboranes Type R_2BX
Synthesis
– alkyl-(1-aninoalkyl)-phenylthioboranes from trialkylboranes, phenyl isocyanide, and benzenethiol 641
– 3-ethyl-3-ethylmethoxyboryl-2-trimethylsilylpentane 310
– *B*-ethyl-*B*-(3-ethyl-2-trimethylsilyl-3-pentyl)-*B*-(1-methyl-3-oxo-1-butenyl)-borane 310
Reactions
– butylthiodibutylborane + ketones + ketene 631 (3134)
– *B*-chlorodialkylboranes + ethyl diazoacetate 118 (2695)
– diethylboryl pivalate + acetophenone 674
– dimethyl-(dimethylamino)-borane + ketene 638
- Diarylboranes and Substitution Products
Reactions
– aminodiphenylboranes + methyl benzenesulfenate 555 (3059)
– azidodiphenylboran + benzonitrile phenylimine 636
– chlorodiphenylborane + 1,3-dicarbonyl compounds 638
- Trialkylboranes
Reactions
– – with 2-alkenals 657
– – with 1-alkenyl ketones 657
– – with alkyl 4-bromo-2-alkenoates + base 646
– – with alkyl diazoacetates 647
– – with 1-alkynes + butyllithium 803 (3252)
– – with 1-alkynylithium 803 (3249)
– – with azidoalkanes 647
– – with *p*-benzoquinone 657
– – with bromomethyl ketones + base 645
– – with carbon monoxide and water 652
– – with chloroacetonitrile + base 646
– – with chlorophosphines 659
– – with ω-diazoacetophenone 647
– – with 2-dimethylaminomethylcyclopentanone 751
– – with dimethylmethylenesulfurane 648
– – with dimethylmethylenesulfurane *S*-oxide 648
– – with 3,4-epoxy-1-alkynes + oxygen 305
– – with hydrogen cyanide 651
– – with 2-lithiofuran 659
– – with 1-methylcyclopropene + alcohols 798 (3229)
– – with nitrosyl chloride 659
– – with phenylisocyanide + benzenebenzenethiol 641
– – with sulfenyl chlorides 659
– – with Wanzlick's carbene 641
– tributylborane + chlorodifluoromethane + lithium triethylcarboxide 641
- Triarylboranes
Reactions
– triphenylborane + 1-alkynyllithium 803 (3249)
– triphenylborane + 1-chloro-2,2-diarylethenyllithium 644
– triphenylborane + dichloromethyllithium 644
– triphenylborane + dimethylmethylenesulfurane 648
– triphenylborane + iminotrimethylaminium ylid 650
– triphenylborane + tritylsodium + carbon monoxide 654
- Type BX_3
Synthesis
– aminodichloroboranes from organodichloroboranes and azido compounds 802 (3244)
Reactions
– chlorobis[dimethylamino]-borane + ketene 638
– tris[dimethylamino]-borane + methyl benzenesulfenate 555 (3059)
- Miscellaneous Types
Reactions
– phenyl-(phenylimino)-borane *in situ* + benzonitrile phenylimine 636
● Boric Acid Esters
Synthesis
– triaryl borates from triarylboranes and trimethylamine oxide 650
● Borinic Acid Esters
- Dialkylborinic Acid Esters
Synthesis
– enol dialkylborinates *in situ* from diazomethyl ketones and trialkylboranes 116 (2682)
– enol dialkylborinates *in situ* from α,β-unsaturated ketones and trialkylboranes 116 (2682)
– 3-ethyl-3-ethylmethoxyboryl-2-trimethylsilylpentane 310
Reactions
– 1-alkenyl dialkylborinates *in situ* + *N*-halosuccinimides 116 (2683)
– enyl borinates + *N*,*N*-dimethylmethaniminium iodide 685 (3159)
– methyl dialkylborinates + bromine 642
– methyl *B*-ethyl-*B*-(3-ethyl-2-trimethylsilyl-3-pentyl)-borinate + triethylaluminum 310
● Boronic Acid Esters
- Alkaneboronic Acid Esters
Reactions
– dialkyl 1-bromo-3,3,3-trichloropropaneboronate + iodide ion 643
● Boronic Acids
- 1-Alkeneboronic Acids
Synthesis
– – from 2-(1-alkenyl)-1,3,2-benzodioxaboroles by hydrolysis 437 (2970)
● Boroxin

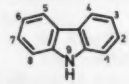
Synthesis
- of the Ring Skeleton
– trimethylboroxin 642
● *C*-Bromo Compounds
- Arylbromomethanes
Synthesis
- from Like Carbon Skeletons
– – from arylcarbinols and dimethyl-(succinimido)-sulfonium bromide 625 (3106)
– 1,3,5-tris[bromomethyl]-benzene 683 (3153)
Reactions
– 1,2-bis[bromomethyl]-benzene + sodium 86
– 1,3-bis[bromomethyl]-benzene + sodium 86
- Bromoalkanes
Synthesis
- from Like Carbon Skeletons
– – from alcohols and bromodimethylsulfonium bromide 798 (3231)
– – from alkanes and *N*-bromodimethylamine 21
– – from alkanes, bromine, and mercuric oxide 227 (2780)
– – from dialkyl ethers and dibromotriphenylphosphorane 175 (2720)
Reactions
– bromomethane + hexafluoroantimonic acid 203
– 1,4-dibromobutane + hexafluoroantimonic acid 203
- Bromoalkenes Type C=C–Br
Synthesis
- from Like Carbon Skeletons
– 1-anilino-2-bromo-1,2-diphenylethylenes from 1-anilino-1,2-diphenylethylenes and *N*-bromosuccinimide 108
- Bromoalkenes Type C=C–C–Br
Synthesis
- from Like Carbon Skeletons
– – from allylic alcohols and dimethyl-(succinimido)-sulfonium bromide 625 (3106)
- from Unlike Carbon Skeletons
– 1,8-dibromo-2,6-octadiene 354
- Bromoarenes
Synthesis
- from Like Carbon Skeletons
– – from arenesulfonyl bromides by desulfonylation in the presence of noble-metal catalysts 55 (2606)
– 2-amino-1-bromophenanthrene 610
– 1-bromophenanthrene 610
- Bromoheteroarenes
Synthesis
– *C*-bromo-*N*-heteroarenes from *N*-heteroarenes and 2,4,4,6-tetrabromocyclohexadienone 548 (3032)
- *vic*-Dibromoalkanes
Synthesis
– 3,4-dibromo-7,8-dioxobicyclo[4.2.0]oct-1(6)-ene 212

- *gem*-Dibromo Compounds
Synthesis
- *from Unlike Carbon Skeletons*
– 1,1-dibromo-1-alkenes from aldehydes, carbon tetrabromide, triphenylphosphine, and zinc 429 (2937)
Reactions
– *gem*-dibromoalkanes + butyllithium + aldehydes or ketones 182 (2751)
- 1,1,1-Tribromo Compounds
Synthesis
- *from Like Carbon Skeletons*
– 2-oxo-6-tribromomethyl-1,2,3,4-tetrahydropyrimidines from the 6-methyl-2-oxo der. and bromine 284
● *N*-Bromo Compounds
see also: Amines, Carboxylic Acid Amides; Sulfonic Acid Amides, etc.
Reactions
– 2-bromocyclohexyl *N*-bromoacetimidate + triethylamine 61 (2627)
● Bromonium Compounds
Synthesis
– 1,4-butanediylbromonium hexafluoroantimonate 203
– dimethylbromonium hexafluoroantimonate 203

● Carbamic Acid Esters
- Alkyl Carbamates
Synthesis
– – from cyanogen chloride and alcohols 690 (3179)
– 1,3-bis[alkoxycarbonylamino]-propanes from dialkyl *N,N'*-alkylidene-bis-carbamates and alkenes 286
– diethyl *N,N'*-(2,4-pentanediyl)-dicarbamate 368 (2894)
– ethyl *N*-cyclopropylcarbamates from cyclopropyl isocyanates and ethanol 31
Reactions
– – *N*-aminomethylation by Mannich reaction 737
– – with formaldehyde 257
– alkyl *N*-(3-oxopropyl)-carbamates + ammonia or primary amines + hydrogen/Raney nickel 279
– alkyl *N*(3-oxopropyl)-carbamates + hydrogen/Raney nickel + heat 279
- Aryl Carbamates
Reactions
– 4-nitrophenyl *N*-hydroxycarbamate + (1.) base, (2.) acid 551 (3040)
● Carbamic Acid Halides
- Carbamoyl Bromides
Reactions
– 2-cyanophenylcarbamoyl bromides + hydrogen chloride 192
- Carbamoyl Chlorides
Reactions
– *N*-(α-chlorobenzylidene)-carbamoyl chloride + alkanenitriles 200
– *N*-(α-chlorobenzylidene)-carbamoyl chlorides + arenecarbonitriles + hydrogen chloride 200
– 2-cyanophenylcarbamoyl chlorides + hydrogen chloride 192
● Carbamimidic Acid Halides



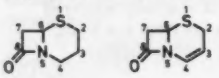
Synthesis
– *N'*-aroyl-*N,N*-dimethylcarbamimidoyl chlorides from dialkylcyanamides and aroyl chlorides 202
– *S*-chloro-*N,N'''*-sulfoniobis[*N,N*-dialkylcarbamimidoyl chloride] chlorides from dialkylcyanamides and sulfur dichloride or thionyl chloride 557 (3067)
– *N'*-chlorosulfonyl-*N,N*-dialkylcarbamimidoyl chlorides from dialkylcyanamides and sulfuryl chloride 557 (3067)
– *N,N*-dialkyl-*N'*-dichlorophosphinothioylcarbamimidoyl chlorides from dialkylcyanamides and thiophosphoryl chloride 557 (3067)
– *N,N*-dialkyl-*N'*-dichlorophosphinylcarbamimidoyl chlorides from dialkylcyanamides and phosphoryl chloride 557 (3067)
– *N,N*-dimethyl-*N'*-dimethylaminocarbonylcarbamimidoyl chloride 631 (3133)
● Carbamodithioic Acid Esters
see: Dithiocarbamic Acid Esters
● Carbamothioic Acid Esters
see: Thiocarbamic Acid Esters
● Carbamoperoxoic Acids
Synthesis
– *N*-arylsulfonylcarbamoperoxoic acids from arylsulfonyl isocyanates and hydrogen peroxide 181 (2745)
– *N*-benzoylcarbamoperoxoic acids from benzoyl isocyanates and hydrogen peroxide 181 (2745)
– *N*-benzoylcarbamoperoxoic acids from benzoyl isocyanates and hydrogen peroxide 236 (2813)
Reactions
– *N*-benzoylcarbamoperoxoic acids + carboxylic acids 236 (2813)
● Carbamoselenothioic Acid Esters
Synthesis
– *S*-(2-oxoalkyl) *N*-phenylcarbamoselenothioates from 2-oxoalkylmercaptans and phenyl isoselenocyanate 236 (2814)
Reactions
– *S*-(2-oxoalkyl) *N*-phenylcarbamoselenothioates + acid 236 (2814)
● Carbazole



Synthesis
- *from Like Ring Skeletons*
– *N*-alkylcarbazoles from carbazoles, alkyl halides, and thallium(I) ethoxide 551 (3041)
– *N*-ethenylcarbazole 439 (2979)
Reactions
- *Retention of the Ring Skeleton*
– – *N*-aminomethylation by Mannich reaction 738
● Carbenes
- Carbene and Homologs (including Acylcarbenes etc.)
Generation
– dialkoxycarbonylcarbenes from dialkyldiazomalonates 139
Stability
– diethoxycarbonylcarbene 138
Reactions
– dialkoxycarbonylcarbenes, CH-insertion reactions with alkanes 138
– α-diazo-ketones + 2-acetoxy-1-alkenes + copper(I) compounds 401
- Dihalocarbenes
Generation
– – from trihalomethanes and thallium(I) ethoxide 317 (2844)
– chlorofluorocarbene, in a two-phase system 112
– dichlorocarbene 452, 800 (3238)
Reactions
– – with alkenes 317 (2844), 452
– dichlorocarbene + bicyclo[3.2.1]-oct-2-ene 800 (3238)
– chlorodifluorocarbene + alkenes 112
- Heterocarbenes
Generation
– chloro-methylthiocarbene 209
Reactions
– chloro-methylthiocarbene + alkenes 209
– 1,3-diphenylimidazolidin-2-ylidene (Wanzlicks carbene) + trialkylboranes 641
● Carbenium Salts
Sythesis
– *t*-alkyl hexafluoroantimonates from *t*-alkyl fluorides and antimony(V) fluoride 492
– *t*-alkyl hexafluoroantimonates from *t*-alkyl halides and hexafluoroantimonic acid 492
– dimethoxycarbenium hexafluorophosphate 490
– methoxycarbenium hexafluoroantimonate 53
– trialkoxycarbenium hexafluorophosphates from dialkyl carbonates and trialkyloxonium hexafluorophosphates 490
– trialkoxycarbenium tetrafluorophosphates from tetraalkyl orthocarbonates and trialkyloxonium hexafluorophosphates 490
– tricyclopropylcarbenium hexafluoroantimonate 493
Reactions
– dimethylaminoethoxycarbenium tetrafluoroborate + sodium cyanide 61 (2631)
● Carbimidic Acid Esters
Reactions
– dialkyl *N*-dimethylphosphinocarbimidates + alkenes 371 (2910)
● Carbocyclic Non-Aromatic Carboxylic Acid Esters
Synthesis
– ethyl 1-alkyl-2-oxocyclopentanecarboxylates from ethyl 2-oxocyclopentanecarboxylate and alkyl halides 316
● Carbocyclic Non-Aromatic Dicarboxylic Acid Esters
Synthesis
– *gem*-dialkoxycarbonylcyclopropanes from alkenes and dialkoxycarbonylcarbenes 138
– diethyl 2-oxocyclopentane-1,1-dicarboxylate 316
Reactions
– diethyl 2,5-dioxocyclohexane-1,4-dicarboxylate + ethylene glycol + tosic acid 665
● Carbocyclic Non-Aromatic Dicarboxylic Acids
Synthesis
– 1,4-cyclohexadiene-3,6-dicarboxylic acid 95
● Carbocyclic Non-Aromatic Nitriles
Synthesis
– 3-cyanocyclopropenes from tetrazolo[*b*]pyridazines by irradiation 370 (2905)
● Carbodiimides
Synthesis

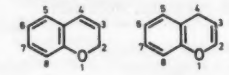
– arylphenylcarbodiimides from benzonitrile oxide and triphenylphosphine *N*-arylimides 482
Reactions
– – with α-hydroxyalkynes 818 (3315)
– – with ketenes 332
– – with methylhydroxylamine 810 (3282)
– diphenylcarbodiimide + triphenylphosphine *N*-phenylimide 482
● Carbohydrazonic Acid Esters
Synthesis
– aryl *N*-phenylarenecarbohydrazonoates from *N*-phenylarenecarbohydrazonoyl bromides and phenols 809 (3277)
● Carbohydrazonic Acid Halides
Reactions
– *N*-phenylarenecarbohydrazonoyl bromides + benzenethiols + base 809 (3277)
– *N*-phenylarenecarbohydrazonoyl bromides + phenols + base 809 (3277)
● Carbohydrazonothioic Acid Esters
Synthesis
– aryl *N*-phenylarenecarbohydrazonothioates from *N*-phenylarenecarbohydrazonoyl bromides and benzenethiols 809 (3277)
● Carbonimidodithioic Acid Esters
Reactions
– dimethyl *N*-cyanocarbonimidodithioate + 1,ω-diaminoalkanes 821 (3328)
● Carbonochloridic Acid Esters
Synthesis
– cyano-*t*-butyl carbonochloridate 240 (2834)
Reactions
– cyano-*t*-butyl carbonochloridate + amino-acids 240 (2834)
● Carbonochloridothioic Acid Esters
Synthesis
– *O*-(2-methoxycarbonylphenyl) carbonochloridothioate 325 (2878)
Reactions
– *O*-(2-methoxycarbonylphenyl) carbonochloridothioate + arylamines 325 (2878)
● Carboranes
Reactions
– azidocarboranes, Curtius degradation 660
– carboranecarboxamides, Hofmann degradation 660
– carboranyl phenyl ketoximes, Beckmann rearrangement 660
– diazoacetylcarboranes, Wolff rearrangement 660
● Carboximidic Acid Esters
Reactions
– alkyl *N*-cyanoalkanimidates + 2,6-diaminopyridine 376 (2930)
– alkyl *N*-dimethylphosphinocarboximidates + alkenes 371 (2910)
– 2-bromocyclohexyl *N*-bromoacetimidate + trimethylamine 61 (2627)
● Carboxylic Acid Amides
- General
Synthesis
- from Like Carbon Skeletons
– – from carboxylic acids, amines, and EEDQ 320 (2856)
– – from carboxylic acids, amines, and titanium(IV) chloride 118 (2693)
– – from carboxylic acids, amines, and triphenyl phosphite/imidazole 320 (2856)
– – from carboxylic acids and (1.) triphenylphosphine/carbon tetrachloride, (2.) amines 60 (2623)
– – from carboxylic acids, primary amines, and thionyl chloride/HMPT 434 (2957)
– – from carboxylic acids, triphenylphosphine, bromotrichloromethane, and amines 60 (2623)
– *N*-(1-alkylsulfonylalkyl)-carboxamides from carboxamides, aldehydes, and sodium alkanesulfinates 742
– *N*-aminomethylcarboxamides from carboxamides, formaldehyde, and secondary amines 737
– *N*-(1-arylsulfonylalkyl)-carboxamides from carboxamides, aldehydes, and sodium arenesulfinates 742
– *N*-substituted carboxamides from isocyanates (*in situ* from acyl chlorides and sodium azide) and alkyl- or aryllithium 678
– – from *O*-mesitylsulfonyl-ketoximes on basic alumina 215
Reactions
– – *N*-aminomethylation by Mannich reaction 736
– – with aryl isocyanates 325 (2877)
– – with formaldehyde and Lewis acids 257
– – with phosphonitrile dichloride 554 (3055)
– *N*-(2-hydroxyalkyl)-carboxamides + zinc + heat 183 (2754)
- *N,N*-Diacylamines
for cyclic Derivatives, *refer to:* Dicarboxylic Acid Imides
Synthesis
– – from *N*-alkylcarboxamides, acetoperoxoic acid, and manganese(II)- or manganese(III) salts 119 (2697)
– *N*-Halocarboxamides
Reactions
– *N*-bromoacetamide + dialkyl sulfides 322 (2865)
- Miscellaneous Types
Reactions
– *N*-substituted *N*-trimethylsilylcarboxamides + diperoxohexamethylphosphoroamidomolybdenum(VI) 369 (2899)
● Carboxylic Acid Anhydrides
Synthesis
– – from carboxylic acids and cyanogen bromide/pyridine 630 (3129)
Reactions
– – with 1-cyanoalkylzinc bromides 120 (2700)
– dichloroacetic anhydride + aldimines 337
● Carboxylic Acid Azides
Synthesis
– – from acyl chlorides and sodium azide 678
– – from acyl chlorides, hydrazoic acid, and pyridine 413
Reactions
– 3-azidocarbonyl-5-oxo-1-phenyl-4,5-dihydropyrazoles + carboxylic acids 633 (3142)
● Carboxylic Acid Bromides
- Alkanoyl Bromides
Synthesis
– – from alkanoic acids and thionyl bromide 612
- Aroyl Bromides
Synthesis
– – from arenecarboxylic acids and thionyl bromide 612
● Carboxylic Acid Chlorides
- General
Reactions
– – with copper(I) cyanide 181 (2743)
– – with hydrazoic acid/pyridine 413
– – with nitriles in the presence of hydrogen chloride 189
– – with sodium tetracarbonylferrate 229 (2786)
– – with trimethylsilyl azide 233 (2800)
– 2*H*-acyl chlorides + imines + triethylamine 330, 334
– 2*H*-acyl chlorides + 2-substituted 5,6-dihydro-4*H*-1,3-thiazines 335
● Carboxylic Acid Esters
- General
Synthesis
- from Heterocyclic Compounds
– – from 2-carbo-substituted 2-methylthio-1,3-dithianes, aqueous ethanol, and mercury(II) salts 630 (3128)
- from Like Carbon Skeletons
– – from carboxylic acids, alcohols, and thionyl chloride/HMPT 434 (2957)
– – from carboxylic acids and dimethylformamide-dialkyl sulfate adducts 62 (2633)
– alkyl carboxylates from methyl carboxylates, alcohols, and potassium cyanide 790
– alkyl carboxylates from sodium carboxylates and alkyl halides in HMPT 689 (3177)
– alkyl carboxylates from tetraalkylaminium carboxylates and alkyl halides 370 (2902)
– alkyl esters of sterically hindered carboxylic acids from the acids, alkyl iodides, and potassium hydroxide 555 (3057)
– butyl carboxylates from carboxylic acids, 1-chlorobutane, copper(I) oxide, and cyclohexyl isocyanide 117 (2691)
– methyl carboxylates from *N,N,N*-trimethylanilinium carboxylates, thermally 495
- from Unlike Carbon Skeletons
– – by alkoxycarbonylation of unsaturated substrates in the presence of transition-metal catalysts 509
– 1-cyanoalkyl carboxylates from 2-oxoalkanenitriles and organomagnesium halides 180 (2742)
Reactions
– – with ethenylmagnesium chloride/copper(I) chloride 230 (2790)
– – with phosphorus(V) sulfide 149
● Carboxylic Acid Fluorides
- General
Synthesis
– – from carboxylic acids and cyanuric fluoride 487
- Aroyl Fluorides
Synthesis
– benzoyl fluorides from benzoic acids and dialkylaminosulfur trifluorides 787
● Carboxylic Acid Hydrazides
see also: Hydrazines
Reactions
- without Cyclization
– – with cerium(IV) ammonium nitrate 350

– – with ketones + sodium cyanide 61 (2630)
● **Carboxylic Acids**
- **General**
Synthesis
- *from Heterocyclic Compounds*
– – from 2-carbo-substituted 2-methylthio-1,3-dithianes, aqueous acetone, and mercury(II) salts 630 (3128)
- *from Like Carbon Skeletons*
– – from carboxylic acid hydrazides and cerium(IV) ammonium nitrate 350
– – from primary alcohols and sodium ruthenate 548 (3029)
- *from Unlike Carbon Skeletons*
– – by hydroxycarbonylation of unsaturated substrates in the presence of transition-metal catalysts 509
– – from aldehydes and tosylmethyl isocyanide 61 (2634)
– – from ketones and tosylmethyl isocyanide 62 (2634)
Reactions
– – with cyanogen bromide + pyridine 630 (3129)
– – with ethylmagnesium chloride/copper(I) chloride 230 (2790)
– – with thionyl bromide 612
– – with trimethylaluminum 228 (2781)
– αH-carboxylic acids, aminomethylation by Mannich reaction 725
- **Miscellaneous Types**
Synthesis
– (carboxycyclopentadienyl)-tricarbonylmanganese 360
– ferrocenecarboxylic acid 360
● **Cephalosporins and Relatives**



Cepham 3-Cepham

Synthesis
– 6-aryl-7-phenylacetylamino-cephams from *N*-(chlorocarbonylmethyl)-phthalimide, 2-aryl-5,6-dihydro-4*H*-1,3-thiazines, and phenylacetyl chloride (3 steps) 335
– 3-methyl-7β-phenylacetylamino-3-cephem-4-carboxylic acid 702 (3228)
– 7-substituted 6-phenylcephams from 2-phenyl-5,6-dihydro-4*H*-1,3-thiazine and alkanoyl chlorides 439 (2977)
● **Cephams**
see: Azeto[2,1-*b*][1,3]thiazine 1,5, 6,7a-Tetrahydro-2*H*,4*H*-; Cephalosporins and Relatives
– definition 328
● **Cephems**
– definition 328
● ***C*-Chloro Compounds**
- **Arylchloromethanes**
Synthesis
- *from Like Carbon Skeletons*
– – from arylcarbinols and dimethyl-(succinimido)-sulfonium chloride 625 (3106)
- *from Unlike Carbon Skeletons*
– benzyl chlorides from benzenes, paraformaldehyde, and hydrogen chloride 621
– polymethylbenzyl chlorides from polylmethylbenzenes, paraformaldehyde, and hydrogen chloride 620
Reactions
– 1,3-bis[chloromethyl]-benzene + sodium 88
- **Chloroalkanes**
Synthesis
- *from Like Carbon Skeletons*
– – from alcohols and thionyl chloride 430 (2939)
– – from alkanes and *N*-chloroamines 19
– – from alkylmercaptans and (1.) chlorocarbonylsulfenyl chloride, (2.) triphenylphosphine 1- 114 (2672)
– 1-chlorooctane-^{36}Cl 448
cyclohexane derivatives from the (a)-chloro derivatives and lithium chloride 549 (3035)
– tertiary chloroalkanes from tetrasubstituted ethylenes and hydrogen chloride 789
- *from Unlike Carbon Skeletons*
– – from alkanoic acids, lead(IV) acetate, and *N*-chlorosuccinimide 493
Reactions
– – with lead(IV) acetate 576
– 2-chlorobornane + silver nitrate/dimethyl sulfoxide 367 (2888)
– 1,7-dichloro-1,7-dimethyl-4-isopropyldecalin + silver nitrate/dimethyl sulfoxide 367 (2888)
- **Chloroalkenes Type C=C–Cl**
Synthesis
- *from Like Carbon Skeletons*
– – from alkali metal enolates and phosphoryl chloride 111
– – from 1*H*-alkyl ketones, carbon tetrachloride, and triphenylphosphine 684 (3155)
– – from enols and phosphorus(V) chloride 111
– 1-amilino-2-chloro-1,2-diphenylethylenes from 1-anilino-1,2-diphenylethylenes and *N*-chlorosuccinimide 108
– ω-chlorostyrene 684 (3155)
- *from Unlike Carbon Skeletons*
– 2-chloro-1,1-dicyclopropylethylene 318 (2848)
- **Chloroalkenes Type C=C–C–Cl**
Synthesis
- *from Like Carbon Skeletons*
– – from allylic alcohols and dimethyl-(succinimido)-sulfonium chloride 625 (3106)
– – from allylic alcohols and triphenylphosphine/carbon tetrachloride 114 (2673)
– 2-chloromethyl-1-butene 146
Reactions
– 3-chloropropene + dimethyl diazomalonate + irradiation 145
- **Chloroalkynes Type C≡C–Cl**
Synthesis
-*from Like Carbon Skeletons*
– dichloroacetylene 450
- **Chloroarenes**
Synthesis
- *from Like Carbon Skeletons*
– – from arenes and titanium(IV) chloride/peroxytrifluoroacetic acid 56 (2609)
– – from arenesulfonyl chlorides by desulfonylation in the presence of noble-metal catalysts 55 (2606)
– alkylchloroarenes from alkylarenes and *N*-chloropolymaleimide 624 (3103)
- *from Unlike Carbon Skeletons*
– octachloronaphthalene 680
- **Chloroheteroarenes**
Synthesis
– heptachloroisoquinoline 680
Reactions
– 2-chloro-1,3-benzoxazole + *N,N*-dimethylhydrazine 268 (2893)
– 2-chloro-1,3-benzothiazole + *N,N*-dialkylhydrazines 368 (2893)
– *C*-chloro-*N*-heteroarenes + alkylidenetriphenylphosphoranes 187 (2773)
- **1,1-Dichloro-1-alkenes**
Synthesis
– – from alkyl ketones, carbon tetrachloride, and triphenylphosphine 684 (3155)
- ***gem*-Dichloro Compounds**
Synthesis
– 1,1-dichloro-2-hydroxy-2-phenylalkanes from alkyl aryl ketones, butyllithium, and dichloromethane 230 (2788)
Reactions
– 1,1-dichloro-2-hydroxy-2-phenylalkanes + aqueous base 230 (2788)
- **Non Aromatic Heterocyclic *C*-Chloro Compounds**
Synthesis
– 4-chloro-2-oxohexahydropyrimidines from 4-hydroxy-2-oxohexahydropyrimidines and thionyl chloride 270
- **Polychloro Compounds**
Synthesis
– 1,3- and 1,4-bis[trichloroethenyl] tetrachlorobenzenes from diethylbenzenes and chlorine 680
– octachlorostyrene 680
– tetrachloro-(trichloroethenyl)-pyridines from ethylpyridines and chlorine 680
Reactions
– diethylaminotrichloroethylene + butyllithium 402
– tetrachloroethylene + oxirane + quaternary aminium compounds 450
- **1,1,1-Trichloro Compounds**
Reactions
– chloroform + oxirane + tetrabutylaminium bromide + alkenes 452
● **Chlorosulfuric Acid Esters**
Synthesis
– arylene bis[chlorosulfates] from dihydroxyarenes and sulfuryl chloride 632 (3136)
● **Chromene**

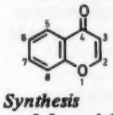


2*H*– 4*H*–

- **2*H*-Chromenes**
see also: Coumarins
Synthesis
- *of the Ring Skeletons*
– – from 3-hydroxy-3-(2-hydroxyphenyl)-1-alkenes, thermally 562 ((3086)
– – from 1-(2-hydroxyphenyl)-1,3-alkadienes, thermally 564 (3091)
- **4*H*-Chromenes**
see also: Chromones, Flavones
Synthesis
- *of the Ring Skeleton*
– – from 2-aminomethylphenols and αH-ketones 770
- **Chromans**
Synthesis
- *of the Ring Skeleton*
– – from *o*-aminomethylphenols and alkenes 770
– 3-acylamino-6,7-dihydroxy-2-oxochromans from *N*-acyl-3,4-dihydroxy-

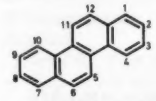
phenyl-L-alanines and iodosobenzene diacetate 562 (3087)
– chroman(2-spiro)-2-oxohexahydropyrimidines from 4-(2-dialkylaminoethylidene)-2-oxohexahydropyrimidines and phenols 284
– chroman(2-spiro-4)-2-thionohexahydropyrimidines from 4-(2-dialkylaminoethylidene)-2-thionohexahydropyrimidines and phenols 284
– 3-hydroxychromans from allyl phenyl ethers and thallium(III) sulfate/sulfuric acid 187 (2772)
– 2-oxochromans from 2-aminomethylphenols and alkanoic acid esters 770
– 2-oxochromans from 2-methyl-1,3-dioxoindane and 4-amino-3-aminomethylbutanones 772
Reactions
- *Retention of the Ring Skeleton*
– 3-chromanones, aminomethylation by Mannich reaction 730

● **Chromones**



Synthesis
– 3-formylchromones from 2-hydroxyacetophenones, dimethylformamide, and phosphoryl chloride 699 (3216)

● **Chrysene**



- **1,4,4a,4b,5,6,12,12a-Octahydrochrysenes**
Synthesis
- *of the Ring Skeleton*
– 1,4-dioxo-8-methoxy-4a der. 117 (2690)
- **1,4,4a,4b,5,6,10b,11,12,12a-Decahydrochrysenes**
Synthesis
- *of the Ring Skeleton*
– 1,4-dioxo-8-methoxy-12a-methyl der. 117 (2690)

● **Cumulenes**
- **Tetracumulenes**
Synthesis
– 1,5-bis[4-chlorophenyl]-1,5-di-*t*-butylpentatetraene 29

● **Cyanamides**
Synthesis
– 1-arylalkylidenecyanamides from *N*-(alkylidenamino)-guanidines and lead(IV) acetate 552 (3045)
Reactions
– cyanamide + dimethylmalonyl chloride 202
– cyanamide + oxalyl chloride 202
– cyanamide + 1,3,5-triazine 808 (3273)
– dialkylcyanamides + aroyl chlorides 202
– dialkylcyanamides + carbonyl chloride 202
– dialkylcyanamides + phosphoryl chloride 557 (3067)
– dialkylcyanamides + sulfur dichloride 557 (3067)
– dialkylcyanamides + sulfuryl chloride 557 (3067)
– dialkylcyanamides + thionyl chloride 557 (3067)
– dialkylcyanamides + thiophosphoryl chloride 557 (3067)
– dimethylcyanamide + *N,N*-dimethyldichloromethaniminium chloride 631 (3133)
– disodium cyanamide + benzofuroxan 367 (2890)

● **Cyanines**
- **Cationic Cyanines**
Synthesis
– bis[5-dialkylamino-2-furyl]-methinium salts from 5-dialkylaminofurfurals and phosphoryl chloride 621
– bis[5-dialkylamino-2-thienyl]-methinium salts from 5-dialkylamino-2-formylthiophenes and phosphoryl chloride or tosic acid 621
– bis[dimethylamino-2-selenophenyl]-methinium perchlorate 621
– 3-chloro-3-dimethyliminio-1-pyrrolidinoalkene chlorides from 1-pyrrolidinoalkenes and *N,N*-dimethyldichloromethanimium chloride 367 (2889)
– 3-dimethylamino-1,1,5,5-tetramethyl-1,5-diaza-1,3-pentadienium perchlorate 804 (3255)
– 1,5-diphenyl-1,5-diaza-1*H*-pentadienium perchlorate 791
– 1,1,7,7-tetraalkyl-2,4,6-trichloro-1,3,5,7-tetraaza-1,3,5,7-heptatetraenium chlorides from dialkylcyanamides and carbonyl chloride 202
– 1,1,5,5-tetraphenyl-1,5-diaza-1*H*-pentadienium perchlorate 791
Reactions
– 2,4-dichloro-1,1,5,5-tetramethyl-1,3,5-triaza-1,3-pentadienium chloride + phenylhydrazine 440 (2980)

● **Cyanogen Halides**
Reactions
– cyanogen chloride + alcohols + acetyl chloride (catalyst) 690 (3179)

● **Cycloalkanes**
see also: the individual Cycloalkanes
Synthesis
- *from Unlike Ring Skeletons*
– 2-alkylcycloalkanones from 1-dialkylaminobicyclo[n.1.0]-alkanes and water 806 (3265)
Reactions
- *Retention of the Ring Skeleton*
– cycloalkanones, dehydrogenation with palladium(II) compounds 177 (2727)
- *Ring-Cleavage Reactions*
– cycloalkanones + cerium(IV) ammonium nitrate 348
– 2,3-epoxycycloalkanones + tosyl hydrazide 500 (2996)
– 2-piperidinomethylcycloalkanones, irradiation in aqueous medium 775

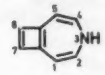
● **Cycloalkenes**
see also: the individual Cycloalkenes
Synthesis
- *from Like Ring Skeletons*
– 2-alkylthio-3-oxocycloalkenes from ethylmethyl-2-oxocycloalkylsulfonium methyl sulfates and *N*-alkylthiophthalimides 556 (3062)
– 2-arylthio-3-oxocycloalkenes from ethylmethyl-2-oxocycloalkylsulfonium methyl sulfates and *N*-arylthiophthalimides 556 (3062)
– 3-methylenecycloalkenes from 1-dimethylaminomethylcycloalkenes by quaternization-fragmentation 549 (3033)
– methyl-substituted polycyclic alkenes from polycyclic *gem*-*N*-benzoylaminomethyl compounds and phosphorus(V) oxide 114 (2674)
– 3-oxocycloalkenes from cycloalkanones and palladium(II) compounds 117 (2727)
- *of the Ring Skeleton*
– 1,2-dimethoxycarbonylcycloalkenes from dimethyl α,α'-dibromoalkanedioates and sodium hydride 628 (3119)
Reactions
- *Fusion of New Rings*
– 2-dialkylsulfonio-3-oxocycloalkene methyl-sulfates + β-dicarbonyl compounds + base 560 (3080)

● **Cycloalkynes**
see also individual Cycloalkynes
Reactions
- *Retention of the Ring Skeleton*
– – catalytic hydrogenation 461

● **Cyclobutabenzene**

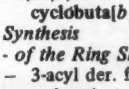
- **1,2-Dihydrocyclobutabenzenes**
Synthesis
- *from Like Ring Skeletons*
– 1,2-dioxo derivative 212
- *of the Ring Skeleton*
– – from 3-oxoisochroman by thermolysis 107

● **Cyclobuta[*d*]azepine**



3*H*–
- **5a, 7a-Dihydro-3*H*-cyclobuta[*d*]-azepines**
Synthesis
- *of the Ring Skeleton*
– 1,5-dimethoxycarbonyl-2,4-diphenyl-3-methyl der. 376 (2932)

● **Cyclobuta[*b*]indole**



1*H*–
- **2,2a,3,7a-Tetrahydro-1*H*-cyclobuta[*b*]indoles**
Synthesis
- *of the Ring Skeleton*
– 3-acyl der. from 1-acylindoles and activated 1-alkenes, irradiation 815 (3305)

● **Cyclobutanes**
Synthesis
- *from Like Ring Skeletons*
– 2-cyanocyclobutanones from 1-amino-2(4)-cyanocyclobutenes by hydrolysis 115 (2678)
Synthesis
- *of the Ring Skeleton*
– cyclopropane(spiro-1)-cyclobutane(3-spiro)cyclopropane 427
– 2-hydroxy-2-methylcyclobutanone 402
Reactions
- *Ring-Cleavage Reactions*
– 1-alkoxy-1,2-dialkyl-2-hydroxycyclobutanes + periodic acid 402
- *Transformation of the Ring Skeleton*
– 1,3-dioxotetramethylcyclobutane + phenylmethanimines 330

● **Cyclobutenes**
Synthesis
- *of the Ring Skeleton*
– 1-amino-2-cyanocyclobutenes from 2-alkenenitriles and ynamines 115 (2678)

– 1-amino-4-cyanocyclobutenes from 2-alkenenitriles and ynamines 115 (2678)
– 1,2-dimethoxycarbonylcyclobutene 628 (3119)

Reactions
- *Fusion of New Rings*
– 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene + paraformaldehyde 355
– 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene + triethyl orthocarboxylates 355
- *Ring-Cleavage Reactions*
– cyclobutene-1,2-dicarboxylic acid der., thermolysis 807 (3268)

● **Cyclodecenes**

Synthesis
- *from Like Ring Skeletons*
– *cis*-cyclodecene 461

● **Cyclododecadienes**

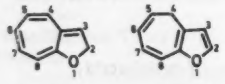
Synthesis
- *from Like Ring Skeletons*
– *cis, cis*-1,7-cyclododecadiene 461

Reactions
– 3,6,9,12-tetraoxo-1,7-cyclododecadiene + methylamine 102

● **Cyclododecanes**

Reactions
– 1,4-dioxocyclododecane + ammonia 101
– 1,4,7,10-tetraoxocyclododecane + methylamine 102

● **Cyclohepta[*b*]furan**



2*H*– 4*H*–

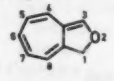
- **2*H*-Cyclohepta[*b*]furans**

Reactions
- *Transformation of the Ring Skeleton*
– 2-oxo der. + cyanoacetamide + base 55 (2605)
– 2-oxo der. + malodinitrile + base 55 (2605)

- **3a,5,6,7,8,8a-Hexahydro 4*H*-cyclohepta[*b*]furans**

Synthesis
- *of the Ring Skeleton*
– 8-oxo der. from 2-ethylmethylsulfonio-3-oxocycloheptene methyl sulfate and β-dicarbonyl compounds 560 (3080)

● **Cyclohepta[*c*]furan**

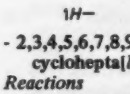


1*H*–

- **3,8a-Dihydro-1*H*-cyclohepta[*c*]-furans**

Synthesis
- *of the Ring Skeleton*
– 8a-alkoxycarbonyl-1-oxo der. from alkylbenzenes and dialkyl diazomalonates 144

● **Cyclohepta[*b*]pyridine**

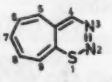


1*H*–

- **2,3,4,5,6,7,8,9-Octahydro-1*H*-cyclohepta[*b*]pyridines**

Reactions
- *Transformation of the Ring Skeleton*
– 1-acetyl der. + butyl nitrite + acid 313

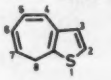
● **Cyclohepta[*e*]-1,2,3-thiadiazine**



- **2,5,6,7,8,9-Hexahydrocyclohepta-[*e*]-1,2,3-thiadiazines**

Synthesis
- *of the Ring Skeleton*
– 2-aryl der. from 1-arylhydrazonomethyl-2-thiocyanatocycloheptenes and perchloric acid 225

● **Cyclohepta[*b*]thiophene**



8*H*–

- *of the Ring Skeleton*
– 5-halo der. from 1,1-dihalo-1a,2,3,6b-tetrahydro-1*H*-cyclopropa[*e*][1]benzothiophenes 812 (3291)

● **Cycloheptatrienes**

- General

Synthesis
- *of the Ring Skeleton*
– – from alkynes and 1a,5a-dihydrocyclopropa[*d*]pyridazines 367 (2887)

Reactions
- *Retention of the Ring Skeleton*
– cycloheptatriene + ammonium nitrate + trifluoroacetic anhydride 624 (3105)
– cycloheptatriene-7-carboxylic acid + cerium(IV) ammonium nitrate 350

- **Cycloheptatrienones (Tropones)**

Synthesis
- *from Like Ring Skeletons*
– aminomethyltropolones from tropolone, formaldehyde, and amines 734

Reactions
- *Retention of the Ring Skeleton*
– tropolone, aminomethylation by Mannich reaction 734

● **Cyclohexadienes**

- **1,3-Cyclohexadienes**

Synthesis
- *of the Ring Skeleton*
– 5-ethoxycarbonyl-4,6,6-trimethyl-1,3-cyclohexadiene 60 (2626)

- **1,4-Cyclohexadienes**

Synthesis
- *from Like Ring Skeletons*
– 1,4-cyclohexadiene 431 (2943)
– 4,4'-diamino-1,3,5,1',3',5',-hexamethyl-bi-cyclohexadienyl 10
– 3,6-dicarboxy-1,4-cyclohexadiene 95
– *p*-xylylene *in situ* 94

Reactions
- *Retention of the Ring Skeleton*
– 1-methoxy-1,4-cyclohexadienes + dichloromaleic anhydride 431 (2942)

● **Cyclohexanes**

Synthesis
- *from Like Ring Skeleton*
– 2-chloro-1,3-dioxo-2-(2-pentynyl)-cyclohexane 406
– 3,3-dichloro-1,2-dioxocyclohexanones and copper(II) chloride 683 (3151)
- *of the Ring Skeleton*
– 1,3-bis[methylene]-cyclohexane 427

Reactions
- *Retention of the Ring Skeleton*
– 2,6-unsubstituted cyclohexanones + copper(II) chloride 683 (3151)
- *Ring-Cleavage Reactions*
– 2-nitrocyclohexanone + ammonia 627 (3115)
– 2-nitrocyclohexanone + 1, ω-diaminoalkanes 627 (3115)
- *Transformation of the Ring Skeleton*
– 2-chloro-1,3-dioxo-2-(2-pentenyl)-cyclohexane + sodium carbonate 406

● **Cyclohexenes**

Synthesis
- *from Like Ring Skeletons*
– 1-amino-2-nitrocyclohexenes from 2-nitrocyclohexanone and primary amines 627 (3115)
– 3-oxocyclohexene 177 (2727)
- *of the Ring Skeleton*
– 4-acylcyclohexenes from butadiene and 2-aminoalkyl ketones 769
– 5-alkyl-6-ethoxycarbonyl-1-hydroxy-
– 3-oxocyclohexenes from ethyl acetoacetate and alkyl 2-alkenoates 627 (3116)
– 3-oxocyclohexenes from dimethyl 2,6-dioxoalkanephosphonates and base 425
– 3-oxocyclohexenes from ethyl 6-diethylamino-3-methyl-4-oxohexanoate methiodide and ethyl 3-oxobutanoates 213

Reactions
- *Retention of the Ring Skeleton*
– cyclohexene + disuccinoyl peroxide 156

● **Cyclononadienes**

- **1,2-Cyclononadienes**

Synthesis
- *of the Ring Skeleton*
– – from 9,9-dibromobicyclo[6.1.0]-nonane and alkyllithium 29, 32

- **1,5-Cyclononadienes**

Synthesis
- *of the Ring Skeleton*
– *cis, cis*-1,5-cyclononadiene 366 (2885)

● **Cyclononens**

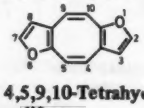
Synthesis
- *from Like Ring Skeletons*
– *cis*-cyclononene 461

● **Cyclooctadienes**

- **1,5-Cyclooctadines**

Reactions
- *Transformation of the Ring Skeleton*
– 2,3-dibromo der. + acetic anhydride + zinc chloride 801 (3240)

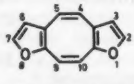
● **Cycloocta[1,2-*b*;5,6-*b'*]difuran**



- **4,5,9,10-Tetrahydroxycycloocta[1,2-*b*;5,6-*b'*]-difurans**

Synthesis
- *of the Ring Skeleton*
– – from 2-methyl-3-trimethylaminiomethylfuran hydroxide 93

● **Cycloocta[1,2-*b*;6,5-*b'*]difuran**



- **4,5,9,10-Tetrahydrocycloocta-[1,2-*b*;6,5-*b'*]difurans**

Synthesis
- *of the Ring Skeleton*
– – from 2-methyl-3-trimethylaminomethylfuran hydroxide 93

● **Cyclooctenes**

Synthesis
- *from Like Ring Skeletons*

– phenylcyclooctenes from cyclooctene, benzene, and palladium(II) acetate 531

● **Cyclopentadienes**

- **Cyclopentadienones**

Synthesis

- of the Ring Skeleton

– 2,4-di-*t*-butylcyclopentadienone 614

Reactions

- Transformation of the Ring Skeleton

– tetraarylcyclopentadienones + cerium(IV) ammonium nitrate 349, 564 (3093)

- **Miscellaneous Types**

Synthesis

– dialkylsulfonium cyclopentadiene ylids from diazocyclopentadiene and dialkyl sulfides 811 (3284)

● **Cyclopenta[*b*]furan**

4*H*–

- **3a,5,6,6a-Tetrahydro-4*H*-cyclopenta[*b*]furans**

Synthesis

- of the Ring Skeleton

– 6-oxo der. from 2-ethylmethylsulfonio-3-oxocyclopentene methyl sulfate and β-dicarbonyl compounds 560 (3080)

- **Hexahydrocyclopenta[*b*]furans**

Synthesis

- of the Ring Skeleton

– 4-formyl-5-hydroxy-2-oxo der. 354

● **Cyclopentanes**

Synthesis

- from Like Ring Skeletons

– bis[2-oxocyclopentyl]-ketone 58 (2618)

– *trans*-1,2-dimethylcyclopentane 654

- of the Ring Skeleton

– 3-(3-alkenyl)-2-oxocyclopentanacetic acids from 1-chloro-2-alkenes, 1,5-hexadiene, carbon monoxide, water, and nickel catalysts 515

– cyclopentanones from dialkyl ketones and cyclopropyldiphenylsulfonium tetrafluoroborate (4 steps) 550 (3039)

– 2,5-dioxocyclopentanealkanoic acid esters from 12-alkyl 4-oxododecanedioates and aluminum chloride 404

– 3-methylenecyclopentane(1-spiro)cyclopropane 427

– 2,3,5-trioxocyclopentanealkanoic acids from (ω-1)-oxoalkanoic acids and dialkyl oxalates 411

Reactions

- Transformation of the Ring Skeleton

– 1,3-dioxocyclopentane, photolysis 402

● **Cyclopenta[*b*]pyridine**

5*H*–

- **5*H*-Cyclopenta[*b*]pyridines**

Synthesis

- of the Ring Skeleton

– 2-amino-3,7-dicyano der. from 1,4-diketones and malodinitrile (2 steps) 186 (2771)

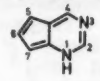
- **6,7-Dihydro-5*H*-cyclopenta[*b*]-pyridines**

Synthesis

- of the Ring Skeleton

– 5,7-dioxo-6-(1-oxoalkyl)-der. from dimethyl pyridine-2,3-dicarboxylate and methyl ketones 186 (2768)

● **Cyclopentapyrimidine**



1*H*–

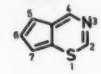
- **2,3,4,5,6,7-Hexahydro-1*H*-cyclopentapyrimidines**

Synthesis

- of the Ring Skeleton

– 3-benzyl-2-oxo der. 766

● **Cyclopenta[*e*]-1,3-thiazine**



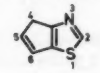
- **2,3,4,5,6,7-Hexahydrocyclopenta[*e*]-1,3-thiazines**

Synthesis

- of the Ring Skeleton

– 2-imino-2,3,4,5,6,7-hexahydroxocyclopenta[*e*]-1,3-thiazine(4-spiro)cyclopentane 282

● **Cyclopenta-1,3-thiazole**



4*H*–

- **4*H*-Cyclopenta-1,3-thiazoles**

Synthesis

- of the Ring Skeleton

– 4-carboxy-2-phenyl der. from thiobenzamides and methyl 3-bromo-2-oxocyclopentanecarboxylate 185 (2765)

● **Cyclopentenes**

Synthesis

- from Like Ring Skeletons

– cyclopentene(3-spiro-3)-cyclopentene 624 (3102)

– 1,4-dimethyl-2-hydroxy-3-oxocyclopentene 750

– 2-hydroxy-3-oxocyclopentene 410

- of the Ring Skeleton

– 4-hydroxy-3-(2-pentenyl)-cyclopentene 408

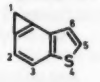
– 3-oxocyclopentene-4-acetic acid 514

– 3-oxocyclopentenes, survey of methods 397

● **Cyclophanes**

see: Phanes

● **Cyclopropa[*e*][1]benzothiophene**



1*H*–

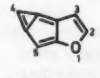
- **1a,2,3,6b-Tetrahydro-1*H*-cyclopropa[*e*][1]benzothiophenes**

Reactions

- Transformation of the Ring Skeleton

– 1,1-dihalo der., transformation by base or thermolysis 812 (3291)

● **Cyclopropa[3,4]cyclopenta[1,2-*b*]-furan**



- **Octahydrocyclopropa[3,4]cyclopenta[1,2-*b*]furans**

Reactions

- Ring-Cleavage Reactions

– 4-hydroxy-2-oxo der. + cerium-(IV) ammonium nitrate 354

● **Cyclopropanes**

Synthesis

- from Like Ring Skeletons

– ethylidenecyclopropane 146

- of the Ring Skeleton

– 1-acyl-2-acyloxycyclopropanes from α-diazo-ketones and 2-acetoxy-1-alkenes 401

– 2-amino-1-hydroxy-1-phenylcyclopropanes from 3-amino-1-oxo-1-phenylpropane by irradiation 775

– 1-benzoyl-2-chloromethylcyclopropanes from diethyl 2-oxo-2-phenylethanephosphonates and chloromethyloxirane 688 (3170)

– *gem*-chlorofluorocyclopropanes from alkenes and dichlorofluoromethane/base 112

– 2-chloromethyl-1,1-dimethoxycarbonylcyclopropane 145

– 1-chloro-1-methylthiocyclopropanes from alkenes and chloromethylthiocarbene 209

– cyclohexylidenecyclopropanes from alkenes, methyl *N*-(1-hydroxycyclohexylmethyl)-*N*-nitrosocarbamates, and base 803 (3250)

– *gem*-dialkoxycarbonylcyclopropanes from alkenes and dialkoxycarbonylcarbenes 138

– *gem*-dichlorocyclopropanes from alkenes, chloroform, oxirane, and tetrabutylaminium bromide 452

– *gem*-dihalocyclopropanes from alkenes, trihalomethanes, and thallium(I) ethoxide 317 (2844)

– 2,2-dimethyl-3-hydroxymethyl-1-(2-methyl-1-propenylidene)-cyclopropane 809 (3275)

– 1,3-dioxo-1,2,3,4-tetrahydroisoquinoline(4-spiro)cyclopropanes from 1,3-dioxo-1,2,3,4-tetrahydroisoquinolines and 1-bromo-2-chloroethane 121 (2705)

– ethenylcyclopropane 146

– 2-methyl-1-methylenecyclopropane 146

– 2-oxo-2,3-dihydroindole(3-spiro)-cyclopropanes from 2-oxo-2,3-dihydroindoles and 1-bromo-2-chloroethanes 121 (2705)

Reactions

- Ring-Cleavage Reactions

– – with fluorosulfuric acid 661

– 1-cyano-1-(2-pyridyl)-cyclopropanes + (1.) acid, (2.) base 204

– cyclopropane + hydrogen fluoride/pyridine 779

– 1,2-diarylcyclopropanes + cerium(IV) ammonium nitrate 351

– *gem*-dibromocyclopropanes + butyllithium 29

– ethyl *N*-cyclopropyl-*N*-nitrosocarbamates + base 31

– phenylcyclopropane + cerium(IV) ammonium nitrate 351

– Transformation of the Ring Skeleton

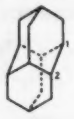
– cyclopropanone + ethanol + sodium azide 343

– cyclopropane ethyl semiacetal + sodium azide 343

– methylenecyclopropane, dimerization in the presence of nickel(0) catalysts 427

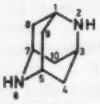
● **Cyclopropa[*d*]pyridazine**

- 1a,5a-Dihydro-1*H*-cyclopropa[*d*]-pyridazines
Reactions
- Transformation of the Ring Skeleton
– – with alkynes 367 (2887)
● **Cyclopropenes**
- Cyclopropene and Carbo-Substituted Cyclopropenes
Synthesis
- of the Ring Skeleton
– 3-cyanocyclopropenes from tetrazolo[*b*]pyridazines by irradiation 370 (2905)
– 1-ethylcyclopropene 146
– tetrasubstituted cyclopropenes from non-terminal alkynes, benzylidene chloride, and methyllithium 611
Reactions
- Ring-Cleavage Reactions
– 1-methylcyclopropene + trialkylboranes + alcohols 798 (3229)
- Cyclopropenones and Cyclopropenethiones
Reactions
- Transformation of the Ring Skeleton
– cyclopropenones + 1-pyrrolidinocyclododecene 430 (2938)
– diphenylcyclopropenone + ammonia 343
– diphenylcyclopropenone + methylamine 343
– diphenylcyclopropenone + 1,2-oxazoles 820 (3323)
– diphenylcyclopropenone + pyrazine 120 (2704)
– diphenylcyclopropenone + pyridazine 120 (2704)
- Hetero-Substituted Cyclopropenes
Synthesis
- from Like Ring Skeletons
– azidotriarylcyclopropenes from triarylcyclopropylium bromides and sodium azide 325 (2875)
Reactions
- Transformation of the Ring Skeleton
– azidotriarylcyclopropenes, thermal rearrangement 325 (2875)
● **Cyclopropylium Salts**
Reactions
– triarylcyclopropylium bromides + sodium azide 325 (2875)
● **Deuterio Compounds**
- *C*-Deuterio Compounds
Synthesis
- by H/D Exchange
– deuterioarenes from arenes and hexadeuteriobenzene 113 (2671)
– 2-octanone-1,1,1,3,3-d_5 453
– pentadeuterioaniline 218
– polydeuterio-*N*-heteroarenes from *N*-heteroarenes and deuterium oxide on platinum asbestos 218
– polydeuteriophenanthrenes from phenanthrene and deuterium oxide on platinum asbestos 218
- by X/D Exchange
– (1*S*)-1,5-anhydro-D-glucitol-1-*d* 238 (2827)
– 2-hydroxymethyl-3,4,5-trihydroxytetrahydropyran-2-*d* 238 (2827)
- Other Methods of Synthesis
– 1-deuterioalkenes from 2-(1-alkenyl)-1,3,2-benzodioxaboroles and acetic-d_4 acid 437 (2970)
– 1-deuterioalkyl ketones from 1-alkenyl ketones, dialkylboranes, and deuterium oxide 657
– 3-deuterio-1-oxo-1-phenylpropane 417
– diazomethane-d_2 115 (2681)
– perfluoroalkanes-1,1,1-d_3 from perfluoroalkanoic acids and acetic-d_3 acid, electrochemically 227 (2779)
– (4*S*)-L-threose-4-*d* 238 (2827)
● **Diamantanes**



Synthesis
- of the Ring Skeleton
– – from a heptacyclo precursor by catalytic hydrogenation 548 (3030)
● **1,3-Diazaadamantanes**

Synthesis
- of the Ring Skeleton
– 5,7-diaryl-6-oxo der. from 1,3-diarylacetones, formaldehyde, and ammonia 708
● **2,6-Diazaadamantanes**



Synthesis
- of the Ring Skeleton
– 4,8-dibromo-2,6-ditosyl der. 699 (3217)
● **1,4-Diazabicyclo[2.2.1]heptane**

- 1,4-Diazoniabicyclo[2.2.1]heptane Salts
Synthesis
- of the Ring Skeleton
– 1,4-bis[2-chloroethyl] der., dichloride 708
● **2,5-Diazabicyclo[2.2.0]hexane**

Synthesis
- of the Ring Skeleton
– 3-oxo der. from 2-oxo-1,2-dihydropyrazines, photochemically 439 (2976)
● **1,5-Diazabicyclo[3.3.1]nonane**

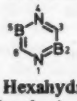
Synthesis
- of the Ring Skeleton
– 2-hydroxy-9-oxo der. from 1-hydroxymethyl-2-oxohexahydropyrimidines and α-branched alkanals 278
● **3,7-Diazabicyclo[3.3.1]nonane**

Synthesis
- of the Ring Skeleton
– 1,5-dialkoxycarbonyl-9-oxo der. from 3,5-dialkoxycarbonyl-4-oxopiperidines, formaldehyde, and ammonia or alkylamines 725
– 1,5-diaryl-9-oxo der. from 1,3-diarylacetones, formaldehyde, and primary amines 708
● **1,4-Diazabicyclo[2.2.2]octane**

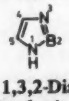
Reactions
- Ring-Cleavage Reactions
– 1,4-diazabicyclo[2.2.2]octane + cerium(IV) ammonium nitrate 353
● **1,5-Diazabicyclo[3.2.1]octane**

Synthesis
- of the Ring Skeleton
– 2-hydroxy-8-oxo der. from 1-hydroxymethyl-2-oxoimidazolidines and α-branched alkanals 278
● **1,3,2,4-Diazadiborete**

- 1,3,2,4-Diazadiboretidines
Synthesis
- of the Ring Skeleton
– octasubstituted der. from chlorobis[dimethylamino]-borane and ketene 638
– tetrasubstituted der. from nitriles and triallylborane 659
● **1,4,2,5-Diazadiborin**



- Hexahydro-1,4,2,5-diazadiborins
Synthesis
- of the Ring Skeleton
– 1,4-diphenyl-2,3,3,5,6,6-hexaalkyl der. from trialkylboranes and phenyl isocyanide 641, 651
– 2,3,3,5,6,6-hexaalkyl der. from trialkylboranes and hydrogen cyanide 651
Reactions
- Transformation of the Ring Skeleton
– octasubstituted der. + aluminum chloride 641
● **1,3,2-Diazaborole**



- 1,3,2-Diazaborolidines
Synthesis
- of the Ring Skeleton
– 2-*t*-alkyl-1,3-diphenyl der. from trialkylboranes and Wanzlick carbene 641
● **1,3,2,4-Diazadiborole**

- 1,3,2,4-Diazadiborolidines
Synthesis
- of the Ring Skeleton
– 2-*t*-alkyl-1,3-diphenyl-4,5,5-trialkyl der. from trialkylboranes and phenyl isocyanide 641

● **1,3,4-Diazaphosphole**

- Tetrahydro-1,3,4-diazaphospholes
Synthesis
- of the Ring Skeleton
– 1,3-dialkyl-2-oxo 4-oxides from *N*-alkoxymethyl-*N,N'*-dialkylureas and nucleophilic phosphorus (III) compounds 245
– 4-halo-2-oxo 4-oxides from alkoxymethylureas and phosphorus(III) halides 288
Reactions
- Ring-Cleavage Reactions
– 4-halo-2-oxo 4-oxides, hydrolysis 288

● **Diazene *N*-Oxides (Azoxy Compounds)**
Synthesis
– *N*-alkoxymethoxy-*N'*-alkyldiazene *N*-oxides from sodium alkylnitramides and chloromethoxyalkanes 302
– *N'*-chloro-*N*-phenyldiazene *N*-oxide 106
Reactions
– diphenyldiazene *N*-oxides + arenesulfonic anhydrides 177 (2726)

● **Diazenes**
- Alkylaryldiazenes
Synthesis
– *t*-alkyl-aryldiazenes from *N*-*t*-alkyl-*N'*-arylureas and *t*-butyl hypochlorite 176 (2725)
- Cyanodiazenes
Reactions
- without Cyclization
– *N*-(4-chlorophenyl)-*N'*-cyanodiazene + 9-diazofluorene 471
- Diaryldiazenes
Synthesis
– – from arenediazonium tetrafluoroborates and copper/acetone 432 (2947)
– *N*-[3-(3-dimethylamino-1-oxopropyl)-phenyl]-*N'*-(2-hydroxy-1-naphthyl)-diazene 717
– 2-hydroxy-1-[4-(1-oxo-3-piperidinopropyl)-phenylazo]-naphthalene-3,7-disulfonic acid, monosodium salt 717
– phenyl-phenylsulfonyloxyphenyldiazenes from diphenyldiazene *N*-oxides and benzenesulfonic anhydrides 177 (2726)
Reactions
- Cyclization Reactions
– diphenyldiazene + ketene 334
- without Cyclization
– – with diazene *in situ* 174 (2711)
– bis[4-diethylaminophenyl]-diazene + cerium(IV) ammonium nitrate 353
- Diazenedicarboxylic Acid Derivatives
Reactions
- Cyclization Reactions
– dialkyl diazenedicarboxylates + ketenes 334
- without Cyclization
– dialkyl diazenedicarboxylates + benzenethiols 691 (3184)
– dialkyl diazenedicarboxylates + dimercaptoalkanes 691 (3184)
- Miscellaneous Types
Synthesis
– aminomethylated diazenes via Mannich reactions 717, 727
– 1,1'-azo-bis[3-methyl-4-phenylimidazolium] dibromides from 1-amino-3-methyl-4-phenylimidazolium bromides and bromine 505 (3014)

● **1,2-Diazepine**

Synthesis
- of the Ring Skeleton
– 1-ethoxycarbonyl-1,2-diazepines from 1-ethoxycarbonyliminopyridinium ylids by irradiation 481

● **1,4-Diazepine**

- 2,3-Dihydro-1,4-diazepinium Salts
Synthesis
- of the Ring Skeleton
– 2,3-dihydro-1*H*-1,4-diazepinium perchlorate 791

● **1,2-Diazete**

- 1,2-Diazetidines
Synthesis
- of the Ring Skeleton
– 3-oxotetraphenyl-1,2-diazetidine 334
Reactions
- Ring-Cleavage Reactions
– 3-oxotetraphenyl-1,2-diazetidine, thermolysis 334

● **Diazirine**

- Diaziridines
Synthesis
- from Like Ring Skeletons
– 1-(nitrophenyl)-diaziridines from diaziridines and 2,4-dinitrofluorobenzene or 1-methoxy-2,4,6-trinitrobenzene 693 (3192)

● **Diazo Compounds**
- 1-Aryldiazoalkanes
Reactions
– aryldiazomethanes + cerium(IV) ammonium nitrate 353
- Diaryldiazomethanes
Reactions
– 9-diazofluorene + *N*-(4-chlorophenyl)-*N'*-cyanodiazene 471
- Diazoalkanes
Synthesis
– diazomethane-d_2 115 (2681)
Reactions
– – with trimethyl trithioborate 647
– diazomethane + phenyl isocyanates 341
– diazomethane + sulfinyl chlorides + alkali metal iodides 811 (3288)
– primary diazoalkanes + 3-oxo-1-alkenylphosphonium bromides 236 (2815)
- 1-Diazoalkyl Sulfones
Synthesis
– bis[arylsulfonyl]-diazomethanes from methylene bis[aryl sulfones] and tosyl azide/base 810 (3283)
– 1-diazoalkyl aryl sulfones from ethyl *N*-nitroso-*N*-(1-tosylalkyl)-carbamates 812 (3290)
– diazomethyl 4-methylphenyl sulfone (tosyldiazomethane) 759
- α-Diazocarboxylic Acid Derivatives
Synthesis
– *N'*-(arylsulfonyl)-diazoacetamidines from aminoacetylenes and arenesulfonyl azides 553 (3051)
– diazomalonic acid esters, review 137
– *N,N*-disubstituted α-phenylsulfonylhydrazono der. and sodium hydride 343
Reactions
– alkyl diazoacetates + trialkylboranes 647
– alkyl diazoacetates + trimethyl trithioborate 647
– benzyl methyl diazomalonates, thermolysis 144
– *t*-butyl 2-diazo-3-oxo-3-piperidinopropanoate, photochemical cyclization 65 (2643)
– dialkyl diazomalonates + alkylbenzenes 144
– dialkyl diazomalonates, decomposition in the presence of alkenes 138
– 3-diazophenylacetyl-5,5-dimethyl-4-methoxycarbonyltetrahydro-1,3-thiazole, irradiation 343
– dimethyl diazomalonate + dimethyl ether, irradiation 144
– dimethyl diazomalonate + dimethyl sulfide, irradiation 144
– dimethyl diazomalonate + 3-chloropropene, irradiation 145
– dimethyl diazomalonate + 1,2,3,4-tetramethylbenzene + trimethyl phosphite-copper(I) iodide 144
– dimethyl diazomalonate + triethylamine + irradiation 144
– ethyl diazoacetate + *B*-chlorodialkylboranes 118 (2695)
- Diazocyclopentadienes
Reactions
– – with dialkyl sulfides, irradiation 811 (3284)
– – with pyridines, irradiation 498 (2990)
- α-Diazo-ketones
Reactions
– – decomposition in the presence of ketene 402
– – with alkenes + copper(I) compounds 401
– – with imines, irradiation 330
– alkyl diazomethyl ketones + trialkylboranes 116 (2682)
– cyclic α-diazo-ketones + alkynes 503 (3009)
– ω-diazoacetophenone + trialkylboranes 647
– 2-diazocetylbenzenesulfonamides + formic acid 506 (3019)

● **Diazonium Betaines**
Reactions
– 2-diazoniobenzoate + 3-hydoxypyridines 375 (2929)

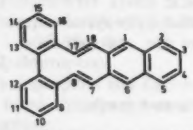
● **Diazonium Salts**
Reactions
- C-N Coupling Reactions
– arenediazonium tetrafluoroborates + copper/acetone 432 (2947)
- Other Reactions
– benzenediazonium tetrafluoroborates + 2,4,6-triphenylphosphorin 437 (2969)

● **Dibenzo[*b,f*]azepine**

5*H*–

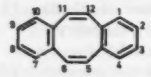
Synthesis
- from Like Ring Skeletons
– *N*-alkyl derivatives from 5*H*-dibenzo[*b,f*]azepine, alkyl halides, and thallium(I) ethoxide 551 (3041)

● **[5,6:7,8]Dibenzocyclodeca[*b*]naphthalene**



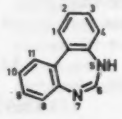
- 7,8,17,18-Tetrahydro[5,6:7,8]dibenzocyclodeca[*b*]naphthalenes
Synthesis
- of the Ring Skeleton
– – from 2,2'-bis[triphenylphosphoranylidenemethyl]-biphenyl and 2,3-bis[bromomethyl]-naphthalene 92

● **Dibenzo[*a,e*]cyclooctene**



- 5,6,11,12-Tetrahydrodibenzo[*a,e*]cyclooctenes
Synthesis
- of the Ring Skeleton
– – from 1,3-bis[bromomethyl]-benzene and sodium 86

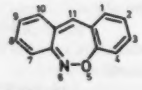
● **Dibenzo[1,3]diazepine**



5*H*–

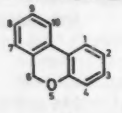
- 6,7-Dihydro-5*H*-dibenzo[1,3]diazepines
Synthesis
- of the Ring Skeleton
– 6-alkyl-5,7-dihydroxy der. from 2,2'-dinitrobiphenyl, alkanals, and reducing agents 326 (2882)

● **Dibenzo[*c,f*][1,2]oxazepine**



Synthesis
- of the Ring Skeleton
– – from acridine 10-oxides by irradiation 376 (2933)

● **Dibenzo[*b,d*]pyran**

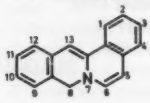


6*H*–

- 6*H*-Dibenzo[*b,d*]pyrans
Reactions
- Transformation of the Ring Skeleton
– 6-oxo der. + ammonia or primary amines 565 (3097)

- 7,8,9,10-Tetrahydro-6*H*-dibenzo[*b,d*]pyrans
Reactions
- Transformation of the Ring Skeleton
– 6-oxo der. + ammonia or primary amines 565 (3097)

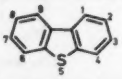
● **Dibenzo[*a,g*]quinolizine**



8*H*–

- 5,6,13,13a-Tetrahydro-8*H*-dibenzo[*a,g*]quinolizines (Berbines)
Synthesis
- of the Ring Skeleton
– 9-hydroxyberbines from 1-(2-hydroxybenzyl)-1,2,3,4-tetrahydroisoquinolines and formaldehyde 723

● **Dibenzothiophene**



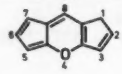
Synthesis
- from Like Ring Skeletons
– 5-oxide 352
Reactions
- Retention of the Ring Skeleton
– dibenzothiophene + cerium(IV) ammonium nitrate 352

● **Dicarboxylic Acid Anhydrides**
- General
Reactions
– – with *t*-butyl carbazate 554 (3053)
- Maleic Anhydrides
Synthesis
– dichloromaleic anhydride 497 (2986)
– 2-ethoxycarbonylamino-maleic anhydride 183 (2753)
Reactions
– – with diazene *in situ* 174 (2711)
– maleic anhydride + *N*-ethoxycarbonylamino-pyridinium betaine 183 (2753)
– maleic anhydride + thionyl chloride/pyridine 497 (2986)
- Succinic Anhydrides
Synthesis
– α-chlorobenzylideneoxo-succinic anhydrides from phenylpropynoic acids and oxalyl chloride 695 (3201)

● **Dicarboxylic Acid Imides**
Only Maleimides, Phthalimides, and Succinimides are indexed under this heading. *For all other cyclic imides, refer to* the corresponding Heterocyclic Systems
- General
Synthesis
– – from lactams and alkyl hydroperoxides 119 (2697)
– – from lactams and peroxoic acids 119 (2697)
– *N*-alkylimides from imides, lithium hydride, and alkyl carbonochloridates 184 (2758)
– *N*-aminodicarboximides from dicarboxylic anhydrides and *t*-butyl carbazate 554 (3053)
Reactions
– – *N*-aminomethylation by Mannich reaction 738
- *N*-Haloimides
Reactions
– *N*-bromosuccinimide + dimethyl sulfide 625 (3106)
– *N*-chlorosuccinimide + dimethyl sulfide 625 (3106)
- Maleimides
Synthesis
– *N*-aryl-2,3-diphenylmaleimides from diphenylacetylene, carbon monoxide, nitroarenes, and hexadecacarbonylhexarhodium 235 (2812)
– dichloromaleimides from maleimides and thionyl chloride 497 (2986)
– 2-ethoxycarbonylamino-maleimide 183 (2753)
– *N*-phenylmaleimides from maleic acid mono-(*N*-phenylamides), 1-hydroxybenzotriazole, and dicyclohexylcarbodiimide 484
Reactions
– – with thionyl chloride/pyridine 497 (2986)
– maleimide + *N*-ethoxycarbonylaminopyridinium betaine 183 (2753)
- Phthalimides
Synthesis
– *N*-alkoxyphthalimides from *N*-hydroxyphthalimides and alkyl halides 448
- Succinimides
Synthesis
– *N*-(4-benzyloxycarbonylaminobenzoyloxy)-succinimide 44

● **Dicyclopentadiene**
see 4,7-Methanoindene, Octahydro-

● **Dicyclopenta[*b,e*]pyran**



1*H*–

- 2,3,5,6,7,8-Hexahydro-1*H*-dicyclopenta[*b,e*]pyrans
Synthesis
- of the Ring Skeleton
– 8-oxo der. from 1-morpholinocyclopentenes and carbonyl chloride 58 (2618)

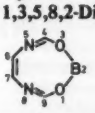
● **Dienecarboxamides (conjugated)**
- 2,4-Alkadienamides
Synthesis
– 3-(cyclododecen-1-yl)-2-alkenamides from 1-pyrrolidinocyclododecene and cyclopropenones 430 (2938)

● **Dienecarboxylic Acid Esters (conjugated)**
- 2,4-Alkadienoic Acid Esters
Synthesis
– – from alkyl 2-alkynoates and 1-alkenylcopper 119 (2699)
– – from alkyl 2-alkynoates and lithium bis[1-alkenyl]-cuprates 119 (2699)
– alkyl 2,4-pentadienoates from acetylene, carbon monoxide, and alcohols 511
– methyl 6-halo-2,4-hexadienoates from 4-halo-2-butenals and methoxycarbonylmethylene-triphenylphosphorane 794
Reactions
– alkyl 2,4-pentadienoates + butyl- or vinylcopper 807 (3267)
– alkyl 2,4-pentadienoates + lithium bis[1-alkenyl]-cuprates 118 (2692)

● **Dienecarboxylic Acids**
Synthesis
– 3-oxo-6,8-nonadienoic acid 399

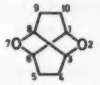
● **Dienedicarboxylic Acid Esters (conjugated)**
Synthesis
– – from acetylene, carbon monoxide, and alcohols 511
– dialkyl butadiene-2,3-dicarboxylates from dialkyl cyclobutene-1,2-dicarboxylates, thermally 807 (3268)

● Dienes (conjugated)
- General
Synthesis
- from Like Carbon Skeletons
– – from enynes by catalytic hydrogenation 462
- from Unlike Carbon Skeletons
– – from 1-haloalkenes and copper 113 (2669)
Reactions
- Cyclization Reactions
– – with oxygen, irradiation 507 (3023)
- Diene Hydrocarbons
Synthesis
- from Like Carbon Skeletons
– – from 4-hydroxy-1,2-alkadienes and lithium alanate 429 (2934)
– – from 4-hydroxy-1-tetrahydropyranyloxy-2-alkynes and lithium alamate 429 (2934)
– 3-methylenecycloalkenes from 1-dimethylaminomethylcycloalkenes by quaternization-fragmentation 549 (3033)
- from Unlike Carbon Skeletons
– – from non-terminal alkynes and borane 645
– 1,4-diarylbutadienes from styrylmagnesium bromides and thionyl chloride 550 (3037)
– 1,4-diphenylbutadiene 295
– 1-phenyl-1,3-pentadiene 295
Reactions
- without Cyclization
– butadiene + *t*-butyllithium 559 (3073)
– butadiene + cerium(IV) ammonium nitrate + bromide ion 354
- Functionally Substituted Dienes
Synthesis
- from Heterocyclic Compounds
– sodium 4-(5-tetrazolyl)-1,3-alkadienoxides from tetrazolopyridines and base 132
- from Like Carbon Skeletons
– 1-alkylthiobutadienes from 1,4-bis[dialkylsulfonio]-2-butene dibromides (2 steps) 557 (3064)
– 1,1-bis[4-fluorophenyl]-butadiene 450
– 1-and 2-(4-nitrobenzoyloxy)-1,3-dienes from 1-alkyl-2-alkynyl 4-nitrobenzoates and silver trifluoroacetate 807 (3270)
– pentadienals from 5-dialkylamino-2-pentenals, thermally 748
- from Unlike Carbon Skeletons
– 1-chloro-4-cyclohexylbutadiene 800 (3237)
– 2,3-dicyanobutadiene 807 (3268)
– 4,4-dimethyl-2-oxo-6-styryl-1,2,3,4-tetrahydropyrimidines from 2-oxo-4,4,6-trimethyl-1,2,3,4-tetrahydropyrimidines and benzaldehyde 283
– *cis, cis*-2,4-hexadienedinitriles from *o*-phenylenediamines and oxygen/copper(I) chloride 369 (2900)
– 6-hydroxymethyl-1,3,7-octatriene 67 (2653)
– 1-oxo-1,3,5-triphenyl-2,4-hexadiene 674
– 1,2,3,4-tetraethoxycarbonyl-butadiene 113 (2669)
Reactions
- Cyclization Reactions
– benzylidenediphenylmethylenesuccinic anhydrides, irradiation 118 (2694)
– 2-bromomethylbutadiene + 2,4,6-trimethylphenol + sodium hydride 802 (3247)
– 1-(2-hydroxyphenyl)-1,3-alkadienes, thermal cyclization 564 (3091)
● Diketene
Reactions
– – with N^1-arylbiguanides 536
● Dinitriles
Synthesis
– 1,1-dicyanoisochroman 297
– *cis,cis*-2,4-hexadienedinitriles from *o*-phenylenediamines and oxygen/copper(I) chloride 369 (2900)
● Diols (including *O*-Protected Derivatives)
see also: Enediols
- General
Synthesis
– 1,n-diacetoxy-*n*-alkanes from *n*-alkenols by hydroalumination and oxidation/acetylation 625 (3107)
– mono-*O*-tritylalkanediols from diols, Merrifield chlorocarbonyl-resin, and trityl chloride 228 (2783)
Reactions
– – three-step mono-*O*-tritylation 228 (2783)
- 1,2-Diols
Synthesis
– – from alkenes and disuccinoyl peroxide 156
– 1,2-bis[trimethylsiloxy]-1,2-diphenylethanes from benzaldehydes and bis[trimethylsilyl]-mercury 318 (2849)
– cycloalkane-1,2-diols from cycloalkenes and potassium permanganate 498 (2989)
– *dl*-1,2-dihydroxy-1,2-diphenylethane 664
– 1,2-dihydroxy-1,2-diphenylethanes from benzaldehydes and bis[trimethylsilyl]-mercury 318 (2849)
– 1,2-dihydroxy-1,2-diphenylethanes from 2,3-dihydroxy-3-phenylpropanoic acid and base 664
– *threo*-1,2-dihydroxy-1-(4-methylphenyl)-2-phenylethane 664
– 6,6-dimethyl-3-hydroxymethylbicyclo[3.1.1]heptane 116 (2686)
– 1,2-ditosyloxyethane 450
– mono-*O*-acetyl-*vic*-diols from 2-dimethylamino-1,3-dioxolanes and acetic acid 187 (2774)
– optically active alkane-1,2-diols from hydroxymethyl ketones by reduction with *saccharomyces cerevisiae* 625 (3109)
Reactions
- Cyclization Reactions
– – with 4,5-dihydroxy-2-oxoimidazolidines 249
– – with *N,N*-dimethylcarboxamide dimethyl acetals 187 (2774)
- without Cyclization
– – with manganese(IV) oxide 805 (3258)
– aryl-substituted 1,2-diols + thallium(III) nitrate 806 (3266)
- 1,3-Diols
Reactions
- Cyclization Reactions
– – with 4,5-dihydroxy-2-oxoimidazolidines 249
- without Cyclization
– 3-branched 1,3-dihydroxyalkanes + hydrogen peroxide/acid 70 (2664)
- 1,4-Diols
Synthesis
– – from 4-hydroxyalkanals and lithium alanate 696 (3206)
– 1,4-diacetoxyalkanes from enol acetates, diisobutylalane, and acetic anhydride 628 (3120)
– 1,1-diaryl-1,4-dihydroxybutanes from benzophenones and *O*-protected 3-hydroxypropylmagnesium bromide 176 (2724)
Reactions
- Cyclization Reactions
– – with tosic acid 696 (3206)
- without Cyclization
– 1,4-diformyloxy-2-alkynes, thermal copper-catalyzed decarboxylation 614
- 1,5-Diols
Reactions
- Cyclization Reactions
– 1,5-dihydroxypentane + Amberlyst 15 209
● 1,3,5,8,2-Dioxadiazaboronin



- Hexahydro-1,3,5,2-dioxadiazaboronins
Synthesis
- of the Ring Skeleton
– – from 2-phenyl-1,3,2-diazaborolidines and chloral 656
● 1,4,2,5-Dioxadiborin

- Tetrahydro-1,4,2,5-dioxadiborins
Synthesis
- of the Ring Skeleton
– hexaalkyl der. from trialkylboranes and carbon monoxide 652
● 2,7-Dioxatwistanes



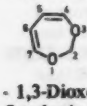
Synthesis
- of the Ring Skeleton
– – from 9-oxabicyclo[6.1.0]non-4-ene (3 steps) 376 (2931)
● 1,2,4-Dioxazole

Synthesis
- of the Ring Skeleton
– 5-aryl-3-oxo der. from *N*-benzoylcarbamoperoxoic acids and acid 236 (2813)
● 1,4,2-Dioxazole

Synthesis
- of the Ring Skeleton
– cycloalkane(spiro-3)-2-methyldihydro-1,4,2-dioxazole(5-spiro)cycloalkanes from cycloalkanones, and strong base 561 (3082)
– 3-phenyl-5-sulfonylimino-der. from benzohydroximic

acid and *N*-dichloromethylene-sulfonamides 323 (2870)

● **1,3-Dioxepin**



- **1,3-Dioxepans**

Synthesis

- of the Ring Skeleton

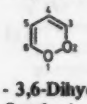
– 2-methoxy-2-methyl der. from 1,4-diols and trimethyl orthoacetate 689 (3175)

Reactions

- Ring-Cleavage Reactions

– 2-alkoxy-2-alkyl der. + trityl chloride 689 (3175)

● **1,2-Dioxin**



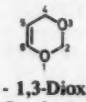
- **3,6-Dihydro-1,2-dioxins**

Synthesis

- of the Ring Skeleton

– – from 1,3-dienes and oxygen, irradiation 507 (3023)

● **1,3-Dioxin**



- **1,3-Dioxans**

Synthesis

- of the Ring Skeleton

– – from aldehydes and 1,3-diols 185 (2764)

– 5-benzoylamino-4-oxo-1,3-dioxans from 5-oxo-2-phenyl-4,5-dihydro-1,3-oxazoles and aqueous formaldehyde 792

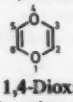
– 2-methoxy-2-methyl-1,3-dioxans from 1,3-diols and trimethyl orthoacetate 689 (3175)

Reactions

- Ring-Cleavage Reactions

– 2-alkoxy-2-alkyl der. + trityl chloride 689 (3175)

● **1,4-Dioxin**



- **1,4-Dioxans**

Reactions

- Retention of the Ring Skeleton

– – with *N*-heteroarenes + peroxy compounds 16

● **1,3-Dioxole**

- **1,3-Dioxoles**

Synthesis

- from Like Ring Skeletons

– 2-thiono-1,3-dioxoles from 2-oxo-1,3-dithioles and phosphorus(V) sulfide 120 (2702)

Reactions

- Retention of the Ring Skeleton

– 2-oxo-1,3-dioxoles + phosphorus(V) sulfide 120 (2702)

- **1,3-Dioxolanes**

Synthesis

- of the Ring Skeleton

– – from aldehydes and 1,2-diols 185 (2764)

– – from carbonyl compounds and oxirane (+ triethylaminium bromide) 451

– 2-dimethylamino-1,3-dioxolanes from *N,N*-dimethylcarboxamide dimethyl acetals and *vic*-diols 187 (2774)

– 2-methoxy-2-methyl-1,3-dioxolanes from 1,2-diols and trimethyl orthoacetate 689 (3175)

Reactions

- Ring-Cleavage Reactions

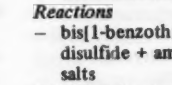
– 2-alkoxy-2-alkyl der. + trityl chloride 689 (3175)

– dimethylamino-1,3-dioxolanes + 95% acetic acid 187 (2774)

- Transformation of the Ring Skeleton

– 2-dimethylamino-4-ethylidene-1,3-dioxolanes, thermolysis 368 (2895)

● **Dipyrido[1,2-*c*:2',1'-*e*]imidazole**



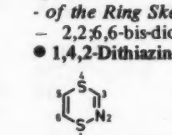
- **Dodecahydrodipyrido[1,2-*c*:2',1'-*e*]-imidazoles**

Synthesis

- of the Ring Skeleton

– – from 2,2'-bipiperidyl and aldehydes 736

● **Dipyrrolo[5',1',2':5",1",2"]-pyridazino[1,2-*a*]pyridazine**



- **Dipyrrolo[5',1',2':5",1",2"]-pyridazino[1,2-*a*]pyridazines**

Synthesis

- from Like Ring Skeletons

– – from the 3,4,7,8-tetrahydro der. 102

- **3,4,7,8-Tetrahydrodipyrrolo-[5',1',2':5",1",2"]pyridazino-[1,2-*a*]pyridazines**

Synthesis

- of the Ring Skeleton

– – from 3,6,9,12-tetraoxo-1,7-cyclododecadiene, hydrazine, and oxygen 102

● **Disulfides**

- **General**

Reactions

– – with dimethyl sulfoxide + sodium cyanide 436 (2963)

- **Chlorocarbonyl Disulfides**

Synthesis

– alkyl chlorocarbonyl disulfides from alkylmercaptans and chlorocarbonylsulfenyl chloride 114 (2672)

Reactions

– alkyl chlorocarbonyl disulfides + triphenylphosphine 114 (2672)

- **Dialkyl Disulfides**

Synthesis

– bis[2-hydroxyalkyl] disulfides from oxiranes and sulfurated sodium borohydride 176 (2723)

Reactions

– – with oxygen + irradiation + sensitizer 811 (3289)

– bis[2-hydroxyalkyl] disulfides + lithium alanate 176 (2723)

- **Diaryl Disulfides**

Synthesis

– bis[pentafluorophenyl] disulfide 52

Reactions

– – with alcohols + cyanide ion 436 (2965)

– – with amines + silver(I) salts 63 (2638)

– – with ammonia, ketones, and silver nitrate 181 (2747)

– bis[pentafluorophenyl] disulfide + chlorine 52

– diphenyl disulfide + carboxylic acids + triphenylphosphine 62 (2635)

- **Heterocyclic Disulfides (Het-S-S-Het, Het-S-S-R)**

Synthesis

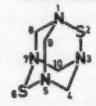
– 1,3,4-oxadiazolyl 4-methylphenyl disulfides from 2-mercapto-1,3,4-oxadiazoles and 4-methylbenzenesulfenyl chloride 322 (2864)

– 1,3,4-thiadiazoyl 4-methylphenyl disulfides from 2-mercapto-1,3,4-thiadiazoles and 4-methylbenzenesulfenyl chloride 322 (2864)

Reactions

– bis[1-benzothiophen-2-yl] disulfide + amines + silver(I) salts 63 (2638)

● **2,6-Dithia-1,3,5,7-tetraazaadamantanes**



Synthesis

- of the Ring Skeleton

– 2,2,6,6-bis-dioxide 261

● **1,4,2-Dithiazine**

- **5,6-Dihydro-1,4,2-dithiazines**

Synthesis

- of the Ring Skeleton

– 2-amino-6-phenyl 4,4-dioxides from styrylsulfonyl-thioureas and base 820 (3325)

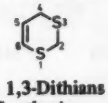
● **1,3-Dithietane**

Synthesis

- of the Ring Skeleton

– – from aldehydes or ketones and *O,O*-diethyl dithiophosphate 117 (2687)

● **1,3-Dithiin**



- **1,3-Dithians**

Synthesis

- from Like Ring Skeletons

– 2-alkylidene-1,3-dithians from 2-lithio-2-trimethylsilyl-1,3-dithian and aldehydes or ketones 692 (3187)

– 2,2-dialkyl-1,3-dithians from 2-alkyl-1,3-dithians 403

– 2-methylthio-1,3-dithians from 2-lithio-1,3-dithians and dimethyl disulfide 630 (3128)

- of the Ring Skeleton

– 2-methoxy-1,3-dithian 65 (2645)

Reactions

- Retention of the Ring Skeleton

– 2-methoxy-1,3-dithian + indoles + titanium(IV) chloride 65 (2645)

- Ring-Cleavage Reactions

– – with cerium(IV) ammonium nitrate 352

– 1,2-bis[2-alkyl-1,3-dithian-2-yl]-ethanes + mercury(II) chloride/mercuric oxide/aqueous methanol 403

– 2-carbo-substituted 2-methylthio-

1,3-dithians + aqueous acetone + mercury(II) salts 630 (3128)
– 2-carbo-substituted 2-methylthio-1,3-dithians + aqueous alcohol + mercury(II) salts 630 (3128)

● Dithiocarbamic Acid Esters
Synthesis
– alkyl dithiocarbamates from *O,S*-dialkyl dithiocarbonates and amines 181 (2744)
– 4-hydroxybenzyl *N,N*-dialkyldithiocarbamates from *p*-phenolic Mannich bases and carbon disulfide 759

● Dithiocarbamic Acids
Reactions
– alkylaminium dithiocarbamates + α-bromo-aldehydes or -ketones 697 (3208)
– ammonium dithiocarbamates + α-bromo-aldehydes or -ketones 697 (3208)

● Dithiocarbonic Acid Esters
- O,S-Esters
Synthesis
– – from alcohols, carbon disulfide, dialkyl sulfates (or alkyl aryl sulfates), and dimsylsodium 63 (2636)
Reactions
– *O,S*-dialkyl dithiocarbonates + primary amines 181 (2744)
– *O,S*-dialkyl dithiocarbonates + secondary amines 181 (2744)

● Dithiocarboxylic Acid Esters
- General
Synthesis
– – from organomagnesium halides and carbon disulfide 557 (3065)
– – from thiocarboxylic acid *S*-esters and phosphorus(V) sulfide 149

- Arenecarbodithioic Acid Esters
Reactions
– aryl arenecarbodithioates + ozone 617
– carboxymethyl arenecarbodithioates + tosylmethyl isocyanide + base 235 (2809)

- Heterocyclic Dithiocarboxylic Acid Esters
Synthesis
– 1-alkylthiothiocarbonyl-1-cyano-3,4-dihydro-1*H*-2-benzothiapyrans from 1-cyano-3,4-dihydro-1*H*-2-benzothiapyrans, phenyllithium, carbon disulfide, and alkyl iodides 297
– 1-alkylthiothiocarbonyl-1-cyanoisochromans from 1-cyanoisochromans, phenyllithium, carbon disulfide, and alkyl iodides 297
– 1-cyano-1-phenylthiothiocarbonyl-3,4-dihydro-1*H*-2-benzothiapyran 297
– 1-cyano-1-phenylthiothiocarbonylisochroman 297

● Dithiocarboxylic Acids
- Arenedithioic Acids
Reactions
– sodium arenecarbodithioates + sodium hydroxylamine-*O*-sulfonate 556 (3063)

● 1,2-Dithiole

- 1,2-Dithiolanes
Synthesis
- from Like Ring Skeletons
– *syn*- and *anti*-4-carboxy-1,2-dithiolane 1-oxides from 4-carboxy-1,2-dithiolane and various oxidizing agents 607
- of the Ring Skeleton
– 4-carboxy-1,2-dithiolane (asparagusic acid) 607
– 4,4-dialkyl-3,5-dioxo-1,2-dithiolanes from dialkyldithiomalonic acids and iodine 559 (3074)
Reactions
- Ring-Cleavage Reactions
– 4-carboxy-1,2-dithiolane + zinc/acetic anhydride 607

● 1,3-Dithiole

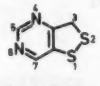
- 1,3-Dithiolanes
Synthesis
- of the Ring Skeleton
– 2-acyl-1,3-dithiolanes from alkane-1,2-bis[sulfenyl chlorides] and α-methylene-carbonyl compounds 120 (2701)
– 2-ethoxyoxoacetyl-1,3-dithiolanes from alkane-1,2-bis[sulfenyl chlorides] and ethyl 3-oxoalkanoates 120 (2701)
– 2-methoxy-1,3-dithiolane 65 (2645)
Reactions
- Retention of the Ring Skeleton
– – with quinoxaline + peroxy compounds 16
– 2-methoxy-1,3-dithiolane + indoles + titanium(IV) chloride 65 (2645)
- Ring-Cleavage Reactions
– – with cerium(IV) ammonium nitrate 352
– 2,2-dialkyl-1,3-dithiolanes + cerium(IV) ammonium nitrate 408
– 2,2-diphenyl-1,3-dithiolane + lithium alanate + copper(II) chloride/zinc chloride 366 (2883)

● [1,2]Dithiolo[2,3-*b*][1,2,5]-oxathiazole

7–S^{IV}–

Synthesis
- of the Ring Skeleton
– – from 3-alkyl-1,2-dithiolium perchlorates and nitrous acid acid 185 (2763)

● 1,2-Dithiolo[4,3-*d*]pyrimidine



- 4,5,6,7-Tetrahydro-3*H*-1,2-dithiolo-[4,3-*d*]pyrimidines
Synthesis
- of the Ring Skeleton
– 3,5-dithiono der. from 6-methyl-2-thiono-1,2,3,4-tetrahydropyrimidines and sulfur 276
– 5-oxo-3-thiono-der. from 6-methyl-2-oxo-1,2,3,4-tetrahydropyrimidines and sulfur 276

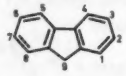
● Diynes (conjugated)
Synthesis
- from Like Carbon Skeletons
– 1-alkene-3,5-diynes from 2,4-diynylaminium iodides by deamination 748
- from Unlike Carbon Skeletons
– – from 1-alkynes, copper(I) chloride, and oxygen 430 (2940)
– diarylbutadiynes from arylethynylmagnesium bromides and thionyl chloride 550 (3037)
Reactions
- Cyclization Reactions
– aryl silylbutadiynyl ketones + hydrazine 47
– bis[trimethylsilyl]-butadiyne + sodium telluride 235 (2810)

● Enamines
Synthesis
– *N*-acylenamines from 2-acylamino-3*H*-alkanenitriles by thermolysis 690 (3178)
– 1-amino-2(4)-cyanocyclobutenes from 2-alkenenitriles and ynamines 115 (2678)
– 1-amino-2-nitrocyclohexenes from 2-nitrocyclohexanone and primary amines 627 (3115)
– 1-dialkylamino-2-halo-1-alkenes from α-halo-aldehydes, dialkylamines, and arsenic(III) chloride 686 (3166)
– 3-dialkylamino-2-phenylpropenenitriles from α-cyanophenylacetonitrile and dialkylamines 61 (2628)
– 2-(1-diethylaminoheptylidene)-3-penten-4-olide 402
– 4-methyl-3-oxo-2-pyrrolidinocyclopentene 405
– 1-(*N*-methyl-*N*-phenylamino)-1-phenylpropene 417
Reactions
- Cyclization Reactions
– – with phenyl isocyanate 342
– 1-(chlorodimethyliminiomethyl)-2-pyrrolidinocyclohexene chloride + hydrazines 375 (2925)
– 1-dimethylamino-2-methylpropene + 4-nitrophenyl phenylmethanesulfonate 534
– 1-morpholinocyclohexene + tetrazoloazines 134
– 1-morpholinocyclopentene + (1.) carbonyl chloride, (2.) water 58 (2618)
– 1-pyrrolidino-1-alkenes + methanesulfonyl chloride + triethylamine 322 (2867)
- without Cyclization
– – with Mannich bases 753
– – with (1.) mercury(II) acetate, (2.) sodium borohydride 115 (2679)
– – with 5-oxo-2-phenyl-4,5-dihydro-1,3-oxazoles 60 (2625)
– 1-anilino-2-bromo-1,2-diphenylethylene + potassium cyanide 109
– 1-amilino-2-bromo-1,2-diphenylethylenes + potassium nitrite 109
– α-amilinostilbenes + *N*-halosuccinimides 108
– diethylaminotrichloroethylene + butyllithium 402
– 1-dimethylamino-2-nitro-1-alkenes + aldehyde phenylhydrazone sodium salts 613
– 1-formylamino-1-tosyl-1-alkenes + sodium methoxide 688 (3172)
– 3-hydroxy-2-pyrrolidinocyclopentenes, acidic hydrolysis 405
– 1-morpholinocyclohexene + malonic acid der. 803 (3248)
– 1-pyrrolidinoalkenes + *N,N*-dimethyldichloromethaniminium chloride 367 (2889)

– 1-pyrrolidinocyclododecene + cyclopropenones 430 (2938)
● **Enediamines**
Synthesis
– – from dialkylaminomethyl ketones and dialkylamines 176 (2721)
Reactions
– 1,2-bis[dialkylamino]-1-alkenes + alkylamines 179 (2734)
● **Enediols and *O*-Derivatives**
- *O*-Derivatives
Reactions
– 7,8-bis[trimethylsiloxy]-bicyclo[4.2.0]octa-3,7-diene + pyridinium hydrobromide perbromide 212
● **Enols (including *O*-Protected Derivatives)**
Synthesis
– 3-acyloxy-2-alkenenitriles from carboxylic anhydrides and 1-cyanoalkylzinc bromides 120 (2700)
– enol acetates from alkenes, acetic acid, oxygen, and palladium(II) salts 595
– 1-nonafluorobutylsulfonyloxycycloalkenes from cycloalkanones, sodium hydride, and nonafluorobutanesulfonyl fluoride 293
Reactions
– – with phosphorus(V) chloride 111
– alkali metal enolates + phosphoryl chloride 111
– *O*-(dialkylboryl)-enols + *N,N*-dimethylmethaniminium iodide 685 (3159)
– 2-trimethylsiloxy-1-alkenes + acyl chlorides 369 (2896)
– *O*-trimethylsilylenols + benzenesulfenyl chloride 371 (2908)
● **Enynes (conjugated)**
Synthesis
- from Like Carbon Skeletons
– 1-alken-3-ynes from 2-alkynylamminium iodides and base 748
– 3-alken-1-ynes from 1-trimethylsilyl-3-alken-1-ynes and potassium fluoride 800 (3239)
– 4-cyclohexyl-1-trimethylsilyl-3-buten-1-yne 800 (3237)
- from Unlike Carbon Skeletons
– 1-trimethylsilyl-3-alken-1-ynes from 3-trimethylsilylpropynylidenephosphoranes and aldehydes 800 (3239)
Reactions
- without Cyclization
– – catalytic hydrogenation 462
– 5-chloro-3-alken-1-ynes + methylmagnesium iodide 56 (2608)
● **Epoxides (Epoxy Compounds)**
see also: Oxirene, Oxiranes
Synthesis
– – from alkenes, disuccinoyl peroxide/dimethylformamide, and sodium hydrogen carbonate 156
Reactions
– – with triphenylphosphine selenide, deoxygenation 684 (3158)
– 2,3-epoxycycloalkanones + tosyl hydrazide, cleavage 500 (2996)
– α-oxo cyclic epoxides + (1.) 1-aminoaziridines, (2.) thermolysis 434 (2956)
● **1,4-Ethanoquinolizine**

1,4-Dihydro-9a*H*-
- Octahydro-1,4-ethanoquinolizines
Synthesis
- of the Ring Skeleton
– 8-oxo der. from 2-(3-oxopropyl)-2-azabicyclo[2.2.2]octanes and mercury(II) acetate 769
● **Ethers**
- General
Synthesis
– 2-haloalkyl ethers from alkyl halides and oxiranes (+ quaternary aminium compounds) 451
Reactions
– alkyl ethers + lead(IV) acetate 575
- 1-Alkenyl Ethers (Enol Ehters)
Synthesis
– bis[3-oxo-1-alkenyl] ethers from ethynyl ketones and diethyl hydrogen phosphate 799 (3235)
– bis[3-oxo-1-alkenyl] ethers from 3-oxoalkanals and diethyl phosphorochloridate 799 (3235)
– 1- and 2-(2-methoxyethenyl)-adamantanes from adamatanecarbaldehydes and methoxymethylenetriphenylphosphorane 604
Reactions
– – with sulfonyl isocyanates 342
– 2-methoxy-3-oxocyclopentene + alkylmagnesium bromides 410
- 2-Alkenyl Ethers
Reactions
– allyl aryl ethers + thallium(III) sulfate/sulfuric acid 187 (2772)
- Alkyl Aryl Ethers
Synthesis
– – from alkali metal phenoxides and dialkyl oxalates 499 (2992)
Reactions
– alkyl trityl ethers + triphenylcarbenium salts 806 (3262)
– methoxyarenes + lithium alanate 796
- Alkyl Heteroaryl Ethers
Synthesis
– alcohols + 4-chloropyridine + sodium hydride 227 (2778)
- 1-Alkynyl Ethers
Synthesis
– 1-ethoxy-1-alkynes from chloroacetaldehyde diethyl acetals, sodium amide, and alkyl bromides 318 (2849)
Reactions
– 2-cyano-1-alkenyl ethyl ethers + 2,6-diaminopyridine 324 (2873)
– 1-ethoxy-1-alkynes + imines 330
- Dialkyl Ethers
Synthesis
– – from secondary or tertiary alcohols, dialkyl sulfate, and dimsylsodium 58 (2616)
Reactions
– – with dibromotriphenylphosphorane 175 (2720)

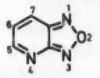
● **Ferrocenes**
- General
Reactions
– – aminomethylation by Mannich reaction 735
- Ferrocene and Hydrocarbon Derivatives
Synthesis
– – from cyclopentadienylthallium, electrochemically, at an iron anode 395
– *trans*-styrylferrocene 530
Reactions
– ferrocene + 1-alkenes + palladium(II) acetate 530
– ferrocene + cerium(IV) ammonium nitrate 354
– ferrocene + 2-chlorobenzoyl chloride + aluminum chloride 360
- Ferrocene Derivatives containing Heterofunctional Groups
Synthesis
– (2-chlorobenzoyl)-ferrocene 360
– *trans*-(2-cyanoethenyl)-ferrocene 530
– dialkylaminomethylferrocenes from ferrocenes, formaldehyde, and dialkylamines 735
– 1-dimethylaminoethylferrocene 309
– 2,2-diphenyl-1,3-dihydroferroceno[*c*]furan 773
– ferrocenecarboxylic acid 360
– 3-ferrocenylpropenal 530
– methyl 3-ferrocenylpropenoate 530
– 1-methylsulfonyloxyethylferrocene 309
Reactions
– (2-chlorobenzoyl)-ferrocene + potassium *t*-butoxide 360
– dimethylaminomethylferrocene, *C*-metallation-electrophilic substitution 774
– 1-hydroxyethylferrocene + methanesulfonyl chloride/trimethylamine 309
– 1-methylsulfonyloxyethylferrocene + dimethylamine 309
● **Fluorene**



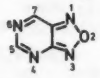
Synthesis
- from Like Ring Skeletons
– dialkylaminofluorenes from fluorene and *N*-chlorodialkylamines 7
– 2-dimethylaminofluorenone 7
● ***C*-Fluoro Compounds**
- *vic*-Difluoroalkanes
Synthesis
– – from alkenes by a halofluorination-fluorination sequence 782
- *gem*-Difluoro Compounds
Synthesis
– – from aldehydes or ketones and dialkylaminosulfur trifluorides 787
– *gem*-difluoroalkanes from alkynes and hydrogen fluoride/pyridine 779
- Fluoroalkanes
Synthesis
- from Like Ring Skeletons
– – from alkenes and hydrogen fluoride/pyridine 779
– *vic*-fluoronitroalkanes from alkenes, hydrogen fluoride/pyridine, and nitronium tetrafluorobotate 785
– secondary fluoroalkanes from secondary alcohols and hydrogen fluoride/pyridine 786
– tertiary fluoroalkanes from tertiary alcohols and hydrogen fluoride/pyridine 786
- from Unlike Carbon Skeletons
– 1,1-dinitro-1-fluoroalkanes from dinitrofluoromethane, silver oxide, and alkyl halides 605
– 1-fluoropropane 779
- Fluoroalkenes Type C=C–F
Reactions
– pentafluoro-2-trifluoromethylpropene + *N*-phenylphenylmethanamine 345
- Fluoroarenes
Synthesis
- from Like Carbon Skeletons
– – from nitroarenes and potassium fluoride 429 (2936)

- Fluoroheteroarenes
Synthesis
- from Like Carbon Skeletons
– – from nitroheteroarenes and potassium fluoride 429 (2936)
– trifluoro-1,3,5-triazine 487
- Polyfluoro Compounds
Synthesis
- from Unlike Carbon Skeletons
– trifluoroethenylpolyhaloarenes from iodotrifluoroethylene and polyhaloarylcopper 684 (3154)
– trifluoroethenyltetrahalopyridines from iodotrifluoroethylene and tetrahalopyridylcopper 684 (3154)
- 1,1,1-Trifluoro Compounds
Synthesis
– diethyltrifluoromethylamine 787
● Fluorosulfuric Acid Esters
Synthesis
– alkyl fluorosulfates from alkenes and fluorosulfuric acid 661
– alkyl fluorosulfates from cyclopropanes and fluorosulfuric acid 661
● Folic Acid and Relatives
Synthesis
– α-fluorofolic acid 44
● Fulvalenes
- Pentaheptafulvalenes
Synthesis
– – from cycloheptatrienones, acetyl tetrafluoroborate, and sodium cyclopentadienide 55 (2604)
● Fulvenes
- Heptafulvenes
Synthesis
- from Like Carbon Skeletons
– – from acetoxy-7-methylcycloheptatrienes 55 (2604)
- Pentafulvenes
Synthesis
- from Unlike Carbon Skeletons
– 6-substituted 6-acyloxypentafulvenes from cyclopentadienylcopper(I)-tributylphosphine and acyl chlorides 366 (2886)
● Furan

- Furans
Synthesis
- from Like Ring Skeletons
– 2-arylfurans from 2-furylcopper and haloarenes 561 (2083)
– 2,5-dimethylfuran 796
– 2-(*cis*-3-hexenyl)-5-methylfuran 400
– 2-styryl- and 2,5-distyrylfuran from furan, styrene, and palladium(II) acetate 530
- of the Ring Skeleton
– – from 1,2-alkadienyldimethyl sulfonium bromides and *CH*-acidic 1*H*,1*H*-alkyl ketones 815 (3302)
– – from butyl 3-oxo-1-alkenyl sulfides and dimethylmethylsulfurane 814 (3301)
– 2,5-dimethylfuran 209
Reactions
- Ring-Cleavage Reactions
– 2-(*cis*-3-hexenyl)-5-methylfuran + sulfuric acid/acetic acid 400
- 2,3-Dihydrofurans
Synthesis
- of the Ring Skeleton
– 2,5-diphenyl der. 418
– 5-ethoxy-4-ethoxycarbonyl-3-oxo der. from diethyl 2-halo-1-oxoalkylmalonates and base 184 (2760)
– 4-methyl-3-oxo der. from 2-dimethylamino-4-ethylidene-1,3-dioxolanes, thermally 368 (2895)
– 3-oxo der. from 2-(2,2-dimethoxyethyl)-2-lithio-1,3-dithiane and ketones (multistage synthesis) 696 (3205)
Reactions
- Transformation of the Ring Skeleton
– 4-benzoyl-2,3-dioxo-5-phenyl der. + benzylideneanilines 679
- 2,5-Dihydrofurans
Synthesis
- from Like Ring Skeletons
– 2-oxo-5-ureido-der. from 5-hydroxy-2-oxo der. and ureas 291
- Tetrahydrofurans
Synthesis
- of the Ring Skeleton
– – from 1,4-diols and tosic acid 696 (3206)
– 2-alkoxy der. from dihydro-4*H*-pyran by ozonolysis and condensation with trialkyl orthoformates 66 (2647)
– 2-alkoxy der. from 4-formyloxybutanal and trialkyl orthoformates 66 (2647)
– 2-alkyl der. from linear alkanols and lead(IV) acetate 406
– 3-(α-chlorobenzylidene)-trioxo der. from phenylpropynoic acids and oxalyl chloride 695 (3201)
– 3-oxabicyclo[3.1.0]hexanes from 2-alkoxymethyl-1,1-dibromocyclopropanes and methyllithium 185 (2762)
Reactions
- Retention of the Ring Skeleton
– – aminomethylation by Mannich reaction 727
- Ring-Cleavage Reactions
– electrochemical reduction of aluminum chloride in tetrahydrofuran 386
- Transformation of the Ring Skeleton
– 2-alkyl-5-oxo der. + polyphosphoric acid 406
● Furazano[3,4-*b*]pyridine



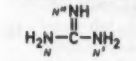
Synthesis
- of the Ring Skeleton
– 3-oxides from 8-nitrotetrazolopyridines 136
● Furazano[3,4-*d*]pyrimidine



Synthesis
- of the Ring Skeleton
– 7-amino 1-oxides from 4-amino-6-chloro-5-nitropyrimidines and sodium azide 136

● Glycerides
Synthesis
– 1-monoglycerides from 1,2-*O*-isopropylideneglycerol and carboxylic anhydrides 628 (3122)
● Glycosides
see also: Monosaccharides and Derivatives
Synthesis
– glycosides of ring-A aromatic 3-hydroxy-steroids from the corresponding 3-hydroxy-steroids, glycosyl bromides, and cadmium carbonate 121 (2706)

● Guanidine and Derivatives



- Guanidine and Carbo-Substituted Guanidines
Reactions
- Cyclization Reactions
– – with 2*H*-alkanals + acid 262
– – with 1-alkenyl ketones 289
– – with *vic*-dicarbonyl compounds 254
– – with formaldehyde + amines 251
– guanidine + acetaldehyde + methylamine 253
- Hetero-Substituted Guanidines
Synthesis
– *N*′,*N*″-disubstituted *N*-hydroxy-
– *N*-methylguanidines from carbodiimides and methylhydroxylamine 810 (3282)
● *C*-Halo Compounds
see also: C-Fluoro Compounds, *C*-Chloro Compounds, *C*-Bromo Compounds, *C*-Iodo Compounds
- *vic*-Dihaloalkanes
Synthesis
– *vic*-bromofluoroalkanes from alkenes, hydrogen fluoride/pyridine, and *N*-bromosuccinimide or bromine/silver nitrate 781
– *vic*-fluoroiodoalkanes from alkenes, hydrogen fluoride/pyridine, and *N*-iodosuccinimide or iodine/silver nitrate 781
- Dihaloalkenes Type -CHal=CHal-
Synthesis
– 1-bromo-2-fluoroalkenes from alkynes, hydrogen fluoride/pyridine, and *N*-bromosuccinimide or bromine/silver nitrate 781
– 1-fluoro-2-iodoalkenes from alkynes, hydrogen fluoride/pyridine, and *N*-iodosuccinimide or iodine/silver nitrate 781
- *gem*-Dihalo Compounds
Synthesis
– 1-chloro-1-fluoro-1-alkenes from chlorofluoromethylenetriphenylphosphorane *in situ* and ketones 113 (2670)
- Haloalkanes
Reactions
– – with tetraalkyaminium carboxylates 370 (2902)
- Haloarenes
Reactions
– – with *N*-chlorodialkylamines 6
● *N*-Halo Compounds
see also: Amines, Carboxylic Acid Amides, Sulfonic Acid Amides, etc.
- *N*-Halo-heterocyclic Compounds
Synthesis
– 1-chloro-1,2,4-triazoles from 1,2,4-triazoles and chlorine 695 (3198)
– 2,5-dioxo-1,3,4,6-tetrachlorooctahydroimdazo[4,5-*d*]imidazoles from the 2,5-dioxo derivatives and chlorine 257
● Heteroarenes
- *N*-Heteroarenes
Synthesis
– *C*-(1-alkenyl)-*N*-heteroarenes from *C*-chloro-*N*-heteroarenes and (1.) alkylidenetriphenylphosphoranes, (2.) aldehydes or ketones 187 (2773)
– *C*-alkyl-*N*-heteroarenes from *C*-chloro-*N*-heteroarenes and alkylidenetriphenylphosphoranes 187 (2773)
– *C*-(1,4-dioxanyl)-*N*-hetero-

arenes from *N*-heteroarenes, 1,4-dioxan, iron(II) sulfate, and *t*-butyl hydroperoxide 16
Reactions
- *Retention of the Ring Skeleton*
– – amination of hydroxy-*N*-heteroarenes via *O*-silylation 69 (2662)
– – radical acylation with aldehydes/iron(II) sulfate/*t*-butyl hydroperoxide 15
– – radical alkylation 12
– – radical hydroxalkylation with alcohols + oxidizing agents 17
– – with *O*-mesitylsulfonylhydroxylamine 549 (3036)
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● **Heterocyclic Carboxamides**
- ***N*-Heterocyclic Carboxamides**
Synthesis
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● **Heterocyclic Carboxylic Acids**
- ***N*-Heterocyclic Carboxylic Acids**
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Synthesis
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- ***N*-Heterocyclic Nitriles**
Synthesis
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see: Phanes
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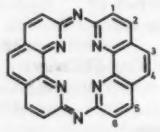

Synthesis
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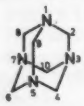

Reactions
- *Ring-Cleavage Reactions*
– – with phosphorus(III) chloride 433 (2950)
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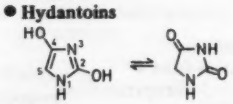

Synthesis
– – from 2,5-dioxooctahydroimidazo[4,5-*d*]imidazoles and acid 254
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Synthesis
– alkyl *N*-arylhydrazine-*N*-carboxylates from sodium *N'*-arylhydrazine-*N*-sulfonate and alkyl carbonochloridates 50
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- **General**
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– trisubstituted hydrazines from *N,N*-disubstituted triphenylphosphine *N*-aminoimides and alkyl iodides 483
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for Simple Carbohydrazides, *refer to:* Carboxylic Acid Hydrazides
Synthesis
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– *N*-acyl-*N*-arylhydrazines from sodium *N'*-arylhydrazine-*N*-sulfonates and acyl chlorides 50
– *N*-acyl-*N*-aryl-*N'*-sulfonylhydrazines from sodium *N'*-arylhydrazine *N*-sulfonates and acyl chlorides 50
– *N*-acyl-*N'*-(1-cyanoalkyl)-hydrazines from acylhydrazines, ketones, and sodium cyanide 61 (2630)
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Reactions
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– – with 5-acetyl-2-oxo-1,2,3,4-tetrahydropyrimidines 290
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- ***N,N*-Diacylhydrazines**
Synthesis
– *N*-aminodicarboximides from dicarboxylic anhydrides and *t*-butyl carbazate 554 (3053)
- ***N,N'*-Diacylhydrazines**
Reactions
- *Cyclization Reactions*
– *N,N'*-diacyl-*N*-(2-halophenyl)-hydrazines + base 564 (3092)
- ***N,N*-Dialkylhydrazines**
Synthesis
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– *N,N*-dimethylhydrazine + 2-alkenoyl chlorides 341
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– – with 2-chloro-1,3-benzothiazole 368 (2893)
– – with 2-chloro-1,3-benzoxazole 368 (2893)
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Synthesis
– – from *N*-acetyl-*N*-alkylhydrazines and aldehydes or ketones (3 steps) 497 (2984)
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Reactions
- *Cyclization Reactions*
– – with formaldehyde 471
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Synthesis
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- **General**
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- *Cyclization Reactions*
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Synthesis
– 6-benzylidenehydrazino-2,4-dioxo-3-methyl-1,2,3,4- tetrahydropyrimidines 300
– 1-hydrazonomethyl-2-thiocyanatocycloalkenes from 1-formyl-2-thiocyanatocycloalkenes and (substituted) hydrazines 225
Reactions
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– 2-nitrobenzaldehyde benzoylhydrazone + triethyl phosphite 363
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– 2-nitrobenzaldehyde phenylhydrazones + triethyl phosphite 363
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- *without Cyclization*
– aldehyde phenylhydrazones + sodium hydride + 1-dimethylamino-2-nitro-1-alkenes 613
- **Ketone Hydrazones**
Synthesis
– 2-nitro-1-alkenyl ketone phenylhydrazones from aldehyde phenylhydranones, sodium hydride, and 1-dimethylamino-2-nitro-1-alkenes 613
Reactions
- *Cyclization Reactions*
– 2-nitroacetophenone phenylhydrazones + triethyl phosphite 363
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– aryl ketones guanylhydrazones + lead(IV) acetate 552 (3045)
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Synthesis
– 2-morpholino-1-nitroacetaldehyde phenylhydrazones from nitroformaldehyde phenylhydrazones, formaldehyde, and morpholine 733
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- *Cyclization Reactions*
– nitroformaldehyde phenylhydrazones + formaldehyde + primary amines 733
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– nitroformaldehyde phenylhydrazones + formaldehyde + secondary amines 733
● **Hydrocarbons**
- *from Like Carbon Skeletons*
– – from ketones and zinc/hydrogen chloride in organic solvents 822 (3332)
- *from Unlike Carbon Skeletons*
– araliphatic hydrocarbons from aromatic aldehydes or ketones and (1.) methyllithium, (2.) lithium 175 (2719)
– 1,1,1-trimethylhydrocarbons from ketones and trimethylaluminum 228 (2781)
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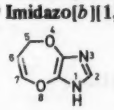
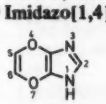
– 1,1,1-trimethylhydrocarbons from carboxylic acids and trimethylaluminum 228 (2781)
Reactions
- *Retention of the Carbon Skeleton*
– araliphatic hydrocarbons + lead(IV) acetate 568
● **Hydroperoxy Compounds**
Synthesis
– 3-hydroxy-*t*-alkyl hydroperoxides from 3-branched 1,3-dihydroxyalkanes and hydrogen peroxide 70 (2664)
● **Hydroquinones**
Reactions
– – with cerium(IV) ammonium nitrate 351, 369 (2898)
● **Hydroximic Acids and Derivatives**
- **Hydroximic Acid Amides (Amide Oximes)**
Reactions
– benzohydroximic acid amides + *N*-dichloromethylenesulfonamides 323 (2870)
- **Hydroximic Acids**
Synthesis
– *N*-substituted hydroximic acids from *N*-substituted *N*-trimethylsilylcarboxamides and diperoxohexamethylphosphoramidomolybdenum(VI) 369 (2899)
Reactions
– benzohydroximic acid + *N*-dichloromethylenesulfonamides 323 (2870)
● **Hydroxylamines**
-*N*-**Alkylhydroxylamines (including *O*-Acyl Derivatives)**
Reactions
– methylhydroxylamine + adamantanone + hydrogen sulfide 561 (3082)
– methylhydroxylamine + adamantanone + sodium hydroxide 561 (3082)
– methylhydroxylamine + carbodiimides 810 (3282)
- *O*-**Alkylhydroxylamines**
Reactions
– – with acetophenones + formaldehyde 718, 719
– – with lithium α-lithiocarboxylates 566 (3100)
- *O*-**Arylhydroxylamines**
Synthesis
– *O*-(4-nitrophenyl)-hydroxylamine 551 (3040)
– *O*-nitrophenylhydroxylamines from halonitrobenzene and *N*-*t*-butoxycarbonylhydroxylamine (2 steps) 57 (2611)
● **Imidazo[*b*][1,4]dioxepin**:



1*H*,5*H*–
- **Hexahydro-1*H*,5*H*-imidazo[*b*][1,4]dioxepins**
Synthesis
- *of the Ring Skeleton*
– 2-oxo der. from 4,5-dihydroxy-2-oxoimidazolidines and 1,3-diols 249
● **Imidazo[1,4]dioxin**



1*H*–
- **Hexahydroimidazo[1,4]dioxins**
Synthesis
- *of the Ring Skeleton*
– 2-oxo der. from 4,5-dihydroxy-2-oxoimidazolidines and *vic*-diols 249
● **Imidazo[4,5-*d*]imidazole**

- **Octahydroimidazo[4,5-*d*]imidazoles**
Synthesis
- *from Like Ring Skeletons*
– 2,5-dioxo-1,3,4,6tetrachloro der. from 2,5-dioxo der. and chlorine 257
– 2,5-dioxo-1,3,4,6-tetrakis[hydroxymethyl] der. from 2,5-dioxo der. and formaldehyde 257
- *of the Ring Skeleton*
– 2,5-diimino der. from *vic*-dicarbonyl compounds and guanidines 254
– 2,5-dioxo der. from *vic*-dicarbonyl compounds and ureas 254
– 2,5-dioxo der. from 4,5-dihydroxy-2-oxoimidazolidines and ureas 254
– 2,5-dithiono der. from *vic*-dicarbonyl compounds and thioureas 254
– 2,5-dithiono der. from 4,5 dihydroxy-2-thionoimidazolidines and thioureas 254
Reactions
- *Ring Cleavage Reactions*
– 2,5-dioxo der. + acid 254
● **Imidazole**

- **Imidazoles**
Synthesis
- *from Like Ring Skeletons*
– 5-bromoimidazoles from imidazoles and 2,4,4,6-tetrabromocyclohexadienone 548 (3032)
– 2,4-dialkylimidazoles from 2,4-dialkyl-5-phenylthioimidazoles and Raney nickel 374 (2923)
- *of the Ring Skeleton*
– 1-acetylamino-4-phenylimidazoles from *N'*-acetylamidrazones and ω-bromoacetophenone 505 (3014)
– 1-amino-4-phenylimidazoles from *N'*-acetylamidrazones and ω-bromoacetophenone 505 (3014)
– 1-cyanoimidazoles from tetrazolo[1,5-*a*]pyrazines by gas-phase pyrolysis 135
– 1-cyanoimidazoles from tetrazolo[1,5-*c*]pyrimidines by gas-phase pyrolysis 135
– 2,4-dialkyl-5-phenylthioimidazoles from alkanal 1-cyanoalkylnitrones and benzenethiols 374 (2923)
– 4,5-diphenylimidazole 136
Reactions
- *Fusion of New Rings*
– histamine + 3-hydroxypyridine-4-carbaldehyde 728
- *Retention of the Ring Skeleton*
– – *N*-aminomethylation by Mannich reaction 739
– 4-oxo der., *N*-aminomethylation by Mannich reaction 739
- **Imidazolium Betaines**
Synthesis

– 1-methylimidazolium 3-dicyanomethylide 470

- 2,3-Dihydroimidazoles
Synthesis
- of the Ring Skeleton
– 4-carboxymethyl-1,3-dialkyl-2-oxo der. from 5-hydroxy-2-oxo-2,5-dihydrofurans and *N,N'*-dialkylureas 291
– 4,5-diphenyl-2-oxo der. 695 (3200)
– 4,5-diphenyl-2-oxo der. from 5,6-diphenyl-3-oxo-2,3,4,5-tetrahydro-1,2,4-triazines by electrochemical reduction 238 (2824)
– 4,5-diphenyl-2-thiono der. from 5,6-diphenyl-3-thiono-2,3,4,5-tetrahydro-1,2,4-triazines by electrochemical reduction 238 (2824)
– 2-oxo-1,4,5-triphenyl der. from 1-anilino-2-bromo-1,2-diphenylethylenes and potassium cyanate 109

- 2,5-Dihydroimidazoles
Synthesis
- from Like Ring Skeletons
– 5-oxo 1-oxides from 5-oxo-imidazolidines and hydrogen peroxide 502 (3004)
- of the Ring Skeleton
– 1-acyl-2,4,5-triphenyl der. from hydrobenzamide and acyl chlorides 504 (3011)
– 2-oxo 3-oxides from *anti*-α-amino-ketoximes and carbonyl chloride 183 (2757)

- 4,5-Dihydroimidazoles
Synthesis
- from Like Ring Skeletons
– 5-oxo 1-oxides from 5-oxo-imidazolidines and hydrogen peroxide 502 (3004)

- Imidazolidines
Synthesis
- of the Ring Skeleton
– 2-cyanoimino der. from dimethyl *N*-cyanocarbonimidodithioate and 1,2-diaminoethanes 821 (3328)
– 1,3-dialkoxycarbonyl der. from alkyl carbamates and formaldehyde 257
– 2,2-dichloro-4,5-dioxo der. 202
– 2-oxo-1,5-diphenyl der. from 3-azido-1,4-diphenyl-2-oxoazetidines, thermally 184 (2759)
Reaction
- Fusion of New Rings
– 4,5-dialkoxy-2-oxo der. + mercaptoethanol 249
– 4,5-dialkoxy-2-oxo der. + thiourea + acid 251
– 4,5-dihydroxy-2-oxo der. + *vic*-diols 249
– 4,5-dihydroxy-2-oxo der. + 1,3-diols 249
– 4,5-dihydroxy-2-oxo der. + mercaptoethanol 249
– 4,5-dihydroxy-2-oxo der. + thiourea + acid 251
– 4,5-dihydroxy-2-oxo der. + ureas 254
– 4,5-dihydroxy-2-thiono der. + thioureas 254
– 1-hydroxymethyl-2-oxo der. + α-branched alkanals + acid 278

● Imidazo[1,4]oxathiin

1H–

- Hexahydroimidazo[1,4]oxathiins
Synthesis
- of the Ring Skeleton
– 2-oxo der. from 4,5-dihydroxy-(dialkoxy)-2-oxoimidazolidines and mercaptoethanol 249

● Imidazo[1,2-*b*]pyridazine

Synthesis
- of the Ring Skeleton
– 6-azido der. 133

● Imidazo[1,2-*a*]pyridine

- Imidazo[1,2-*a*]pyridines
Synthesis
- of the Ring Skeleton
– – from tetrazolopyridine and alkynes 135

- 1,5-Dihydroimidazo[1,2-*a*]pyridines
Synthesis
- of the Ring Skeleton
– 6-cyano-7,8-dimethoxycarbonyl-5-imino-1-methyl der. 476

● Imidazo[1,5-*a*]pyridine

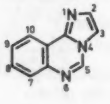
- Octahydroimidazo[1,5-*a*]pyridines
Reactions
- Retention of the Ring Skeleton
– 3-oxo der., *N*-aminomethylation by Mannich reaction 739

● Imidazo[4,5-*c*]pyridine

1H–

- 4,5,6,7-Tetrahydro-1*H*-imidazo[4,5-*c*]pyridines
Synthesis
- of the Ring Skeleton
– – from histamine and 3-hydroxypyridine-4-carbaldehyde 728

● Imidazo[1,2-*c*]quinazoline



- 2,3,5,6-Tetrahydroimidazo[1,2-*c*]quinazolines
Synthesis
- from Like Ring Skeletons
– 5-oxo der. from 5-thiono der. and alkaline hydrogen peroxide 506 (3021)
- of the Ring Skeleton
– 5-thiono der. from 2,4-dithiono-1,2-dihydro-4*H*-3,1-benzothiazines and 1,2-diaminoethane 506 (3021)

● Imidazo[4,5-*d*]-1,3-thiazole

2H–

- Hexahydroimidazo[4,5-*d*]-1,3-thiazoles
Synthesis
- of the Ring Skeleton
– 2-imino-5-oxo der. from 4,5-dihydroxy(dialkoxy)-2-oxoimidazolidines and thiourea 251

● Imides
see: Dicarboxylic Acid Imides, Disulfonic Acid Imides, etc.

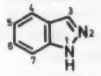
● Imines
- General
Reactions
- Cyclization Reactions
– – with 2*H*-acyl chlorides + triethylamine 330, 334
– – with α-diazo-ketones + irradiation 330
– – with 1-ethoxy-1-alkynes 330
– – with ketenes 330
- Regeneration of the Carbonyl Compound
– *N*-(1,3-benzothiazol-2-ylmethyl)-imines + aqueous oxalic acid 230 (2789)
- without Cyclization
– – with dodecacarbonyltriiron + methanol 498 (2988)

- Aldimines
Synthesis
- from the Corresponding Carbonyl- or Thiocarbonyl Compounds
– *N*-alkyl-1,3-benzothiazol-2-ylmethanimines from 1,3-benzothiazole-2-aldehyde and primary amines 230 (2789)
– *N*-alkyl-2-dialkylaminoalkanimines from 2-dialkylaminoalkanals and alkylamines 178 (2733)
– *N*-phenylalkanimines from aldehydes, phenyl isocyanate, and metal carbonyls 686 (3165)
- Other Methods of Synthesis
– *N*-alkyl-2-dialkylaminoalkanimines from *N*-alkyl-2-bromoalkanimines and alkylamines 178 (2733)
– *N*-alkyl-2-dialkylaminoalkanimines from 2-dialkylaminoalkanal tetraalkylaminals and alkylamines 178 (2733)
– *N*-aryl-2-propenimines from *N,N*-dimethyl-2-propeniminium salts and arylamines 69 (2661)
– *N*-(2-azido-4-dimethylaminophenyl)-phenylmethanimines from benzaldehyde 4-dimethylaminophenylnitrones and hydrazoic acid 299
– *N*-dimethyoxymethylpropanimine 180 (2741)
– *N*-(1-methoxyalkyl)-arylmethanimines from 2*H*-azirines and methanol, irradiation 804 (3256)
Reactions
- Cyclization Reactions
– – with alkyl 2-bromoalkanoates + zinc 338
– – with dichloroacetic anhydride 337
– *N*-alkylalkanimines + chlorocarbonyl isocyanate 237 (2820)
– *N*-benzylalkanimines + 1-isocyanocycloalkanecarboxylic acids 633 (3144)
– *N*,3-diphenyl-2-propenimine + ketenes 332
– *N*-phenylarylmethanimines + 2-chloroalkanoic acids + phosphoryl chloride 338
– phenylmethanimines + 1,3-dioxotetramethylcyclobutane 330

– *N*-phenylphenylmethanimine + diethyl bromoethylmalonate + zinc 331
– *N*-phenylphenylmethanimine + 2,4-diphenyl-5-oxo-1,3-oxazolium betaines 345
– *N*-phenylphenylmethanimine + pentafluoro-2-trifluoromethylpropene 345
- *without Cyclization*
– *N*-arylalkanimines + 1-alkoxycarbonylalkylzinc bromides 566 (3101)
– *N*-arylphenylmethanimines + α*H*-ketones + boron trifluoride 706
– *N*-(2-azido-4-dimethylaminophenyl)-phenylmethanimines, acidic hydrolysis 299
– benzaldimines + chlorocarbonyl isocyanate 433 (2953)
- **Bis-imines**
Synthesis
– 1,2-diphenyl-1-imino-2-phenyliminoethanes from 1-anilino-2-halo-1,2-diphenylethylenes and sodium azide 109
Reactions
– 2,3-bis[alkylimino]-oxetanes + 2-haloalkanoic acids 340
– 2,3-bis[phenylimino]-butane + diphenylketene 332
- **Ketimines**
Synthesis
- *from the Corresponding Carbonyl or Thiocarbonyl Compounds*
– 2-alkylimino-1-dialkylaminoalkanes from dialkylaminomethyl ketones and alkylamines 179 (2734)
– camphor *N*-benzylimines from thiocamphor and benzylamines 535
– 2-cyclohexyliminoalkanes from alkyl methyl ketones and cyclohexylamine 687 (3169)
- *Other Methods of Synthesis*
– 2-alkylimino-1-dialkylaminoalkanes from 2-alkylaminoalkanals and dialkylamines 179 (2734)
– 2-alkylimino-1-dialkylaminoalkanes from 1,2-bis[dialkylamino]-1-alkenes and alkylamines 179 (2734)
– *N*-cyano-1-arylalkanimines from arylketone guanylhydrazones and lead(IV) acetate 552 (3045)
– 1,*N*-diaryl-3-hydroxy-2-alkenimines from 2-anilino-2-arylethyl ketones by irradiation 774
Reactions
– 2-isopropylidenaminobiphenyls, irradiation 821 (3327)
- **Quinone Monoimines**
Synthesis
– 2,6-dimethyl-*p*-benzoquinone 4-(2,4,6-trimethylphenylimine) 353
– 6-oxo-4,5,7-triphenyl-2,6-dihydro-1,3-benzoxazoles from 4-amino-1,3-dihydroxy-2,5,6-triphenylbenzene and ketones 502 (3006)

● **Iminium Salts**
Synthesis
– *N,N*-dimethylchloro-(1-chloro-1-alkenylamino)-methaniminium chlorides from *N*-alkylcarboxamides and *N,N*-dimethyldichloromethaninimium chloride 371 (2906)
– *N,N*-dimethylchloromethaniminium chloride 62 (2632)
– *N,N*-dimethylmethaniminium trifluoroacetate 705
– *N,N*-disubstituted methaniminium perchlorates from tertiary methylamines and trityl perchlorate 705
– 1-hydroxyalkaniminium tetrafluoroborates from carboxamides and tetrafluoroboric acid 810 (3280)
Reactions
– *N,N*-dimethyldichloromethaniminium chloride + *N*-alkyl-2*H*-alkananmides 371 (2906)
– *N,N*-dimethylchloromethaniminium chloride + 1,2-bis[dialkylamino]-ethylenes 629 (3124)
– *N,N*-dimethyldichloromethaniminium chloride + dimethylcyanamide 631 (3133)
– *N,N*-dimethylchloromethaniminium chloride + dimethylformamide 62 (2632)
– *N,N*-dimethyldichloromethaniminium chloride + 1-pyrrolidinoalkenes 367 (2889)
– *N,N*-dimethylmethaniminium trifluoroacetate, reactions with sensitive Mannich substrates 705

● **Indazole**



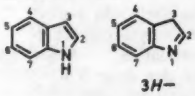
2*H*–

- **Indazoles**
Reactions
- *Retention of the Ring Skeleton*
– – *N*-aminomethylation by Mannich reaction 739
– **2*H*-Indazoles**
Synthesis
- *of the Ring Skeleton*
– 2-anilino-2*H*-indazoles from 2-nitroacetophenones and triethyl phosphite 363
– 2-anilino-2*H*-indazoles from 2-nitrobenzaldehyde phenylhydrazones and triethyl phosphite 363
– 2-benzoylamino-2*H*-indazole 363
– 2-dimethylamino-2*H*-indazole 363
- **4,5,6,7-Tetrahydro-1*H*-indazoles**
Synthesis
- *of the Ring Skeleton*
– 3-dimethylamino der. from 1-(chlorodimethyliminiomethyl)-2-pyrrolidinocyclohexene chloride and hydrazines 375 (2925)
- **4,5,6,7-Tetrahydro-2*H*-indazoles**
Synthesis
- *of the Ring Skeleton*
– 3-dimethylamino der. from 1-(chlorodimethyliminiomethyl)-2-pyrrolidinocyclohexene chloride and hydrazines 375 (2925)

● **Indene**

- **Indenes**
Synthesis
- *from Like Ring Skeletons*
– 1-alkylindenes from indenyllithium and alkyl halides 159
– 1-methylindene 159
- *of the Ring Skeleton*
– 2-arylindenes from 2-aryl-1-(2-hydroxymethylphenyl)-ethanols and polyphosphoric acid 548 (3031)
– 1,1-diphenylindene 531
– 1-oxoindenes from benzoyl chloride-aluminium chloride complexes and alkynes 116 (2683)
- **Indanes**
Synthesis
- *from Like Ring Skeletons*
– 2-acylamino-2-amino-1,3-dioxoindanes from 2-acylamino-2-chloro-1,3-dioxoindanes and ammonia or amines 154
– 2-acylamino-2-benzylthio-1,3-dioxoindanes from 2-acylamino-2-chloro-1,3-dioxoindanes and benzylmercaptan 154
– 2-acylamino-2-chloro-1,3-dioxoindanes from 2-acylamino-1,3-dioxo-2-hydroxyindane and thionyl chloride 154
– 2-acylamino-1,3-dioxo-2-hydroxyindanes from ninhydrin and carboxamides 154
– 2-acylamino-1,3-dioxo-2-(1-imidazolyl)-indanes from 2-acylamino-2-chloro-1,3-dioxoindanes and imidazole 154
– 2-acylamino-1,3-dioxo-2-methoxyindanes from 2-acylamino-2-chloro-1,3-dioxoindanes and methanol 154
– 2-benzoylamino-2-(4,4-dimethyl-2,6-dioxocyclohexyl)-1,3-dioxoindane 154
– 3,3-dimethyl-1-oxoindanes from 1,1-dimethylindanes and chromium(VI) oxide/acetic acid 319 (2835)
Reactions
- *Retention of the Ring Skeleton*
– indane + cerium(IV) ammonium nitrate 351
– 1,1-dimethylindanes + chromium(VI) oxide/acetic acid 319 (2853)
- *Transformation of the Ring Skeleton*
– 2-indanone + hydrogen peroxide + sulfuric acid 107
– 2-oximino-1-oxoindanes + phosphorus(V) chloride 190
- **2,3,3a,4,5,7a-Hexahydroindenes**
Synthesis
- *from Like Ring Skeletons*
– 3-hydroxy der. 801 (3240)
- **Octahydroindenes**
Synthesis
- *from Like Ring Skeletons*
– 4-chloro-4,5-dibromo-1-hydroxy der. 801 (3240)
– 1-hydroxy der. 801 (3240)
- *of the Ring Skeleton*
– 1-acetyl-4-chloro-4,5-dibromo der. 801 (3240)

● **Indole**



3*H*–

- **Indoles**
Synthesis
- *from Like Ring Skeletons*
– – from 3-methylthioindoles and Raney nickel 816 (3308), 819 (3319)
– 3-bromoindoles from indoles and 2,4,4,6-tetrabromocyclohexadienone 548 (3032)
– 3-cyanomethyl-4-nitroindole 750
– 3-(1,3-dithian-2-yl)-indole 65 (2645)
– indole-2-carboxylic acids from 2-alkoxycarbonyl-1-sulfonylindoles and base 561 (3081)
- *of the Ring Skeleton*
2-acylindoles from *N*-(2-acylphenyl)-*N*-(2-oxopropyl or phenacyl)-sulfonamides and (1.) base, (2.) thionyl chloride 561 (3081)

– 2-acylindoles from 2-aminophenyl ketones and bromomethyl ketones 504 (3012)
– 2-benzoylindole 504 (3012)
– 4-cyanoindole from tetrazolo[*a*]quinoline or -isoquinoline by thermolysis 135
– 2-cyanoindoles from *N*-(2-acylphenyl)-*N*-(cyanomethyl)-sulfonamides and (1.) base, (2.) thionyl chloride 561 (3081)
– 2-methoxycarbonylindoles from *N*-(2-acylphenyl)-*N*-(methoxycarbonylmethyl)-sulfonamides and (1.) base, (2.) thionyl chloride 561 (3081)
– 4-methylthioindoles from 2-amino-α-methylthiophenylacetaldehyde and acid 819 (3319)
– 3-methylthioindoles from anilines, *t*-butyl hypochlorite, and methylthioacetaldehyde 819 (3319)
– 3-methylthioindoles from anilines, *t*-butyl hypochlorite, and methylthiomethyl ketones 816 (3308)

Reactions
- Fusion of New Rings
– 1-acylindoles + activated 1-alkenes + irradiation 815 (3305)
– 1-acylindoles + benzoic acid der. + irradiation 694 (3194)
– 1-acylindoles + benzophenone + irradiation 694 (3194)
- Retention of the Ring Skeleton
– – *C*-aminomethylation by Mannich reaction 728
– – *N*-aminomethylation by Mannich reaction 738
– 3-acetoxyindole + benzaldehydes + piperidine 236 (2816)

- 3*H*-Indoles
Synthesis
- from Like Ring Skeletons
– 3,3-disubstituted der. from the 2,3-dihydro der. and manganese(IV) oxide 815 (3303)

- 2,3-Dihydroindoles
Synthesis
- from Like Ring Skeletons
– 1-acetyl-3,3-dialkyl-2-oxo der. from 3-alkyl-2-oxo der. by acetylation, metallation, and alkylation 816 (3306)
– 2-benzylidene-3-oxo der. from 3-acetoxyindole and benzaldehydes 236 (2816)
– 5-dialkylamino-2-oxo der. from oxindole and *N*-chlorodialkylamines 5
– 3,3-dialkyl-2-oxo der. from 3-alkyl-2-oxo der. by *N*-acetylation, alkylation, and deacetylation, 816 (3306)
– 3,3-disubstituted der. from 3,3-disubstituted 2-oxo der. and lithium alanate or sodium bis-[2-methoxyethoxy]-aluminum hydride 815 (3303)
– 2-oxo-2,3-dihydroindole(3-spiro)-cyclopropanes from 2-oxo-2,3-dihydroindoles and 1-bromo-2-chloroethane 121 (2705)

- 4,7-Dihydroindoles
Synthesis
- of the Ring Skeleton
– 4,7-dioxo der. from 2-(1-alkenyl)-3-azido-*p*-benzoquinones, thermally 816 (3309)

● Indolizine

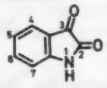
Synthesis
- of the Ring Skeleton
– – from pyridinium alkylids and alkynes 473
– 1,2-diphenyl der. from 2-benzylpyridines and ω-bromoacetophenones (2 steps) 238 (2825)
– 1,2-diphenyl der. from 2-benzylpyridines and ω-bromoacetophenones 238 (2825)
– 1,2-diphenyl der. from 2-benzyl-1-phenacylpyridinium bromides and pyridine 238 (2825)

Reactions
- Retention of the Ring Skeleton
– – aminomethylation by Mannich reaction 728

● *C*-Iodo Compounds
- Iodoalkanes
Synthesis
- from Like Carbon Skeletons
– *vic*-acyloxyiodoalkanes from alkenes, thallium(I) carboxylates, and iodine 799 (3232)
– 1-iodoalkanes from 2-alkylthio-4,5-dihydro-1,3-thiazoles and methyl iodide 228 (2782)
- from Unlike Carbon Skeletons
– 1-iodoalkanes from alkyl chlorides or bromides and (1.) 2-lithiomethylthio-4,5-dihydro-1,3-thiazole, (2.) methyl iodide 228 (2782)

- Iodoalkenes Type C=C–C–C–J
Synthesis
- from Unlike Carbon Skeletons
– – from α,β-unsaturated acetals, diiodomethane, and zinc-copper couple (2 steps) 326 (2881)

● Isatins



Synthesis
- from Like Ring Skeletons
– 1-acylisatins from isatin, sodium hydride, and acyl halides 816 (3307)
– 1-alkylisatins from isatin, sodium hydride, and alkyl halides 816 (3307)

Reactions
- Retention of the Ring Skeleton
– – *N*-aminomethylation by Mannich reaction 738

● Isochromene
see: 1*H*-2-Benzopyran

● Isocyanates
- General
Synthesis
– – from acyl azides, thermally 413
– – from acyl chlorides and sodium azide via Curtius rearrangement 678
– – from acyl chlorides and trimethylsilyl azide 233 (2800)
– – from carboxylic anhydrides and trimethylsilyl azide 233 (2800), 321 (2863)

Reactions
- Cyclization Reactions
– – with diethyl malonate (+ triethylamine) 564 (3094)
- without Cyclization
– – with alkyllithium 678
– – with aryllithium 678
– – with 3,5-diaryl-4,5-dihydropyrazoles 324 (2872)

- Acyl Isocyanates
Reactions
- without Cyclization
– benzoyl isocyanates + hydrogen peroxide 181 (2745)

- 1-Alkenyl isocyanates
Synthesis
– 1-chloro-1-alkenyl isocyanates from nitriles and carbonyl chloride 198
– 2-cyano-1-alkenyl isocyanates from 3-amino-2-alkenenitriles and carbonyl chloride 634 (3148)

Reactions
- Cyclization Reactions
– 1-chloro-2-(4-nitrophenyl)-ethenyl isocyanate + acetonitrile 201
– styryl isocyanates, thermal cyclization 186 (2769)

- Alkyl Isocyanates
Synthesis
– perfluoroalkyl isocyanates from perfluoroalkanoyl chlorides and trimethylsilyl azide 321 (2862)
– trimethylsiloxycarbonylalkyl isocyanates from dicarboxylic anhydrides and trimethylsilyl azide 321 (2863)

Reactions
- without Cyclization
– methyl isocyanate + aldoximes 321 (2861)

- Aryl Isocyanates
Reactions
- Cyclization Reactions
– 2-biphenylyl isocyanate, irradiation 821 (3327)
– 2-cyanophenyl isocyanates + hydrogen halide 192
– phenyl isocyanate + enamines 342
– phenyl isocyanate + ketene dimethyl acetals 342
– phenyl isocyanates + diazomethane 341
- without Cyclization
– – with carboxamides 325 (2877)

- Heterocarbonyl Isocyanates
Synthesis
– *N*-alkyl-*N*-(1-chloroalkyl)-aminocarbonyl isocyanates from *N*-alkylalkanimines and chlorocarbonyl isocyanate 237 (2820)

Reactions
- without Cyclization
– chlorocarbonyl isocyanate + *N*-alkylalkanimines 237 (2820)

- Hetero Isocyanates
Reactions
- without Cyclization
– chlorosulfonyloxy isocyanates + hydrogen peroxide 181 (2745)

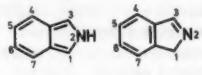
- Sulfonyl Isocyanates
Synthesis
– alkoxysulfonyl isocyanates from chlorosulfonyl isocyanate and alcohols 435 (2962)

Reactions
- Cyclization Reactions
– – with enol ethers 342
– – with 3-penten-4-olide 342
– chlorosulfonyl isocyanate + alkenes 342
- without Cyclization
– – with hydrogen peroxide 181 (2745)
– chlorosulfonyl isocyanate + 1*H*-alkyl ketones 682

● Isocyanides
- General
Synthesis
- from Like Carbon Skeletons
– – from amines, aqueous base, chloroform, and quaternary aminium compounds 453
– – from primary amines and chloroform (+ benzyltriethylaminium hydroxide) 232 (2799)
– – from *N*-substituted formamides,

triphenylphosphine, and diethyl diazenedicarboxylate 435 (2958)
- **2-Alkenyl Isocyanides**
Reactions
-without Cyclization
– allyl isocyanide + *N*-alkylcarboxamides + copper(I) oxide 180 (2741)
– allyl isocyanide + cyclic amines + copper(I) oxide 180 (2741)
- **Alkyl Isocyanides**
Synthesis
- from Heterocyclic Compounds
– 3-hydroxyalkyl isocyanides from oxiranes and 1-lithioalkyl isocyanides 699 (3215)
Reactions
- Cyclization Reactions
– alkyl 2-isocyanoalkanoates + benzaldehydes 701 (3223)
– 3-hydroxyalkyl isocyanides + base or copper(I) oxide 699 (3215)
– 1-isocyanocycloalkanecarboxylic acids + *N*-benzylalkanimines 633 (3144)
– tosylmethyl isocyanide + activated alkenes + base 562 (3085)
– tosylmethyl isocyanide + carboxymethyl arenedithiocarboxylates + base 235 (2809)
- without Cyclization
– alkyl 2-isocyanoalkanoates + benzoyl chlorides 701 (3223)
– 1-lithioalkyl isocyanides + oxiranes 699 (3215)
– tosylmethyl isocyanide + adamantanone + base 320 (2859)
- **Aryl Isocyanides**
Reactions
- without Cyclization
– – irradiation in methanol 688 (3173)
– – with sulfur 181 (2746)

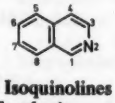
● **Isoindole**



1*H*–

- **1*H*-Isoindoles**
Reactions
– *Transformation of the Ring Skeleton*
– 3-amino-1-imino der. + (1.) bromine/base, (2.) potassium thiocyanate 696 (3203)
- **1,3-Dihydroisoindoles**
Synthesis
- of the Ring Skeleton
– 1-oxo-2-phenyl der. from *o*-phthaldialdehyde, nitrobenzenes, and carbon monoxide 323 (2871)

● **Isoquinoline**



- **Isoquinolines**
Synthesis
- from Like Ring Skeletons
– 1-acylamino der. from 2-acyliminoisoquinolinium ylids by irradiation 698 (3214)
– 1-alkyl der. from isoquinoline, alkanoic acid, and oxidizing agents 13
– 1-(1,4-dioxanyl) der. from isoquinolines by radical alkylation 16
– 1-hydroxymethyl der. from isoquinolines by radical alkylation 17
- of the Ring Skeleton
– 1,3-dichloro der. from 2-cyanomethylbenzoic acids and phosphorus(V) chloride 190
– 1,3-dichloro der. from 2-oximino-1-oxoindanes and phosphorus(V) chloride 190
– 1,3-dichloro der. from 2-phenylalkanenitriles, hydrogen chloride, and carbonyl chloride 197
– heptachloro der. 680
Reactions
- Retention of the Ring Skeleton
– – radical alkylation 13
- **Isoquinolinium Salts**
Synthesis
- from Like Ring Skeletons
– 2-aminoisoquinolinium mesitylenesulfonates from isoquinolines and *O*-mesitylsulfonylhydroxylamine 549 (3036)
Reactions
- Retention of the Ring Skeleton
– 2-aminoisoquinolinium iodide + acyl chlorides 698 (3214)
- **Isoquinolinium Ylids**
Synthesis
– 2-acyliminoisoquinolinium ylids from 2-aminoisoquinolinium iodide and acyl chlorides 698 (3214)
Reactions
– 2-acyliminoisoquinolinium ylids, irradiation 698 (3214)
- **1,2-Dihydroisoquinolines**
Synthesis
- of the Ring Skeleton
– 3-chloro-5-methyl-1-oxo der. from 1-chloro-2-(2,6-dimethylphenyl)-ethenyl isocyanates 201
– 3-chloro-1-oxo der. from 2-cyanomethylbenzoic acids and phosphorus(V) chloride 190
– 3-chloro-1-oxo der. from 2-oximino-1-oxoindanes and phosphorus(V) chloride 190
– 1-oxo der. from styryl isocyanates, thermally 186 (2769)
- **1,2,3,4-Tetrahydroisoquinolines**
Synthesis
- from Like Ring Skeletons
– 1,3-dioxo-1,2,3,4-tetrahydroisoquinoline(4-spiro)cyclopropanes from 1,3-dioxo-1,2,3,4-tetrahydroisoquinolines and 1-bromo-2-chloroethane 121 (2705)
– 1-hydroxy-2-phenyl der. from 2-phenyl-3,4-dihydroisoquinolinium bromides and aqueous base 160
- of the Ring Skeleton
– – from 1-amino-2-phenylethanes and formic acid 505 (3015)
– – from benzylaminoacetaldehyde dialkyl acetals 769
Reactions
- Fusion of New Rings
– 1-(2-hydroxybenzyl) der. + formaldehyde 723
- **5,6,7,8-Tetrahydroisoquinolines**
Synthesis
- of the Ring Skeleton
– *N*-substituted 7,8-dicarboximides from 4-ethenylpyridine and *N*-substituted maleimides 630 (3127)

● **Isoselenocyanates**
Reactions
– phenyl isoselenocyanate + 1-mercaptoalkyl ketones + triethylamine 236 (2814)

● **Isothiocyanates**
- **General**
Reactions
- without Cyclization
– – with 1-cyanoisochroman carbanions 297
– – with 3,5-diaryl-4,5-dihydropyrazoles 324 (2872)
– – with 3,4-dihydro-1*H*-2-benzothiapyran carbanions 297
- **Acyl Isothiocyanates**
Reactions
- without Cyclization
– – with dialkylamines 691 (3182)
- **Alkyl Isothiocyanates**
Reactions
- Cyclization Reactions
– – with aldehydes 375 (2926)
– – with ketones 375 (2926)
- without Cyclization
– – with 2-phenylethylenesulfonamides 820 (3325)
- **Aryl Isothiocyanates**
Synthesis
– – from anilines and thiocarbonyl chloride 631 (3132)
– – from aryl isocyanides and phenyl isothiocyanate 181 (2746)
– – from aryl isocyanides and sulfur 181 (2746)
– phenyl isothiocyanates from benzene derivatives and isocyanatoamine 232 (2798)
Reactions
- Cyclization Reactions
– – with ketene arylimines 693 (3193)
– 2-cyanophenyl isothiocyanates + hydrogen halide 192
– 2-methoxycarbonylphenyl isothiocyanate + 3-amino-1-alkynes 426
- **Hetero Isothiocyanates**
Reactions
- Cyclization Reactions
– isothiocyanatoamine + 4-methylaniline 232 (2798)
- without Cyclization
– isothiocyanatoamine + aniline 232 (2798)
– isothiocyanatoamine + phenol 232 (2798)
- **Heterocarbonyl Isothiocyanates**
Reactions
- without Cyclization
– alkoxycarbonyl isothiocyanates + secondary amines 691 (3182)

● **Isothiourea and Derivatives**
Synthesis
– *N*-(2-aminocarbonylphenyl)-*S*-methyl-*N'*-tosylisothiourea 326 (2879)
– *N,N'*-bis[aminoiminomethylthiomethyl]-*N,N'*-dialkylurea hydrochlorides 248
Reactions
– *S*-alkyl-*N*-phenylisothiourea hydrobromides + isopentyl nitrite 690 (3180)

● **Isourea and Derivatives**
Synthesis
– *N,N*-dialkyl-*O*-methylisoureas from *N,N*-dialkylcyanamides, potassium cyanide, and methanol 801 (3243)
Reactions
– *O*-methyl-*N*-nitroisourea + 2,4-diaminobutanoic acid + (1.) copper(II) sulfate, (2.) hydrogen sulfide 370 (2904)

● **Jasmone and Relatives**
Synthesis
– 2',3'-didehydrojasmone 401
– dihydrojasmone 398, 400
– *cis*-jasmone 398, 400
– methyl jasmonate 461

● **Ketene Derivatives**
- **Ketene *O,O*-Acetals**
Synthesis
– dialkoxyketene dialkyl acetals (tetraalkoxyethylenes) from dialkyl 4-chlorophenyl orthoformates and sodium hydride 321 (2860)
– diaryloxyketene diaryl acetals from chlorodiaryloxymethane and sodium hydride 321 (2860)
Reactions
– chloroketene dimethyl acetal + α,β-unsaturated aldehydes or ketones 236 (2817)
– ketene *O*-(*t*-butyldimethylsilyl) *O*-ethyl acetal + acyl chlorides + base 808 (3272)
– ketene dimethyl acetals + phenyl isocyanate 341
- **Ketene *S,S*-Acetals**
Synthesis
– 2-alkylidene-1,3-dithians from 2-lithio-2-trimethylsilyl-1,3-dithian and aldehydes or ketones 692 (3187)
– benzoylketene *S,S*-dialkyl acetals from alkyl 3-oxo-3-phenylpropanedithioates, alkyl halides, and thallium(I) ethoxide 812 (3292)
– phenylketene dimethyl dithioacetal *S*-oxides from methyl methylthiomethyl sulfoxides and benzaldehydes 119 (2696)
Reactions
– phenylketene dimethyl dithioacetal *S*-oxides + hydrochloric acid + ethanol 119 (2696)
- **Ketene Imines**
Reactions
– ketene arylimines + aryl isothiocyanates 693 (3193)
● **Ketenes**
- **General**
Reactions
- *Cyclization Reactions*
– – with carbodiimides 332
– – with dialkyl diazenedicarboxylates 334
– – with 5,6-diphenyl-2,3-dihydropyrazine 332
– – with imines 330
- *without Cyclization*
– – with 1-methyl-3,4-dihydroisoquinoline 332
- **Diacylketenes**
Reactions
- *Cyclization Reactions*
– dibenzoylketene *in situ* + benzylideneanilines 679
- **Dihaloketenes**
Reactions
- *Cyclization Reactions*
– dichloroketene + *N*,3-diphenyl-2-propenimine 332
- **Ketene and Homologs**
Reactions
- *Cyclization Reactions*
– – with α-diazo-ketones 402
– diphenylketene + *N*-acylhydrazones 331
– diphenylketene + 2,3-bis[phenylimino]-butane 332
– diphenylketene + diphenyldiazene 334
– diphenylketene + nitrosoarenes 333
– diphenylketene + 2-substituted 4,5-dihydro-1,3-thiazoles 331
- *without Cyclization*
– – with β-dicarbonyl compounds 61 (2629)
– diphenylketene + benzaldehyde phenylnitrone 333

● **Ketones**
- **General**
Synthesis
- *from Heterocyclic Compounds*
– – from 2-carbo-substituted 5,6-dihydro-4*H*-1,3-oxazines, methyl iodide, and organomagnesium halides 805 (3261)
– – from cyclic *S,S*-acetals and cerium(IV) ammonium nitrate 352
– – from cyclic *S,S*-acetals and thallium(III) trifluoroacetate 499 (2994)
- *from Like Carbon Skeletons*
– – from alkylamines and 2-formyl-1,3-benzothiazoles (3 steps) 230 (2789)
– – from *sec*-alkyl trityl ethers and triphenylcarbenium salts 806 (3262)
– – from ketone *S,S*-acetals and *O*-mesitylhydroxylamine 312
– – from ketoximes and aluminum triisopropoxide 433 (2952)
– – from ketoximes and cerium(IV) ammonium nitrate 349
– – from secondary alcohols and dimethyl-(succinimido)-sulfonium chloride 628 (3118)
– – from semicarbazones and cerium(IV) ammonium nitrate 349
– alkyl ketones from 1-alkenyl ketones and trifluoroacetic acid/triethylsilane 421
– alkyl ketones from 1-bromoalkyl ketones and pentacarbonyliron 687 (3168)
– 1-phenylthioalkyl ketones from *O*-trimethylsilylenols and benzenesulfenyl chloride 371 (2908)
- *from Unlike Carbon Skeletons*
– – from *vic*-diols by cleavage with manganese(IV) oxide 805 (3258)
– – from 2-oxoalkanenitriles and organomagnesium halides 180 (2742)
– alkyl ketones from acyl chlorides and lithium dialkylcuprates 178 (2730)
– 3,3-bis[phenylthio]-alkyl ketones from 1-alkenyl ketones and lithium bis(1,1-bis[phenylthio]-alkyl)-cuprates 434 (2954)
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– 3-hydroxy-2-buten-4-olides from 2-ethoxycarbonyl-4-oxo-4,5-dihydrofurans and aqueous base 184 (2760)
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– 4-alkanolides + polyphosphoric acid 406
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– 4-butanolide + thionyl chloride + zinc chloride 538
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● Macrocyclic Alkynes (>C_{12})
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● Macrocyclic Allenes (>C_{12})
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● Malonic Acid Esters
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● Mercaptans

- General
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Synthesis
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– 1,3-dimercaptobenzene 436 (2964)
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- without Cyclization
– – with aldehyde 1-cyano-alkylnitrones 374 (2923)
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● Metal Complexes

- Chelate Complexes
Synthesis
– copper chelate of dihydro-[1,3,5,8,10,12]hexaazacyclotetradeca[*klmna*, *k'l'm'n'a'*]bis[1,10]-phenanthroline 64 (2640)
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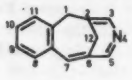
– π-cyclooctenyl-1,5-cyclooctadienecobalt 390
Reactions
– chloro-σ-(2,2-dichloroethenyl)-*trans*-bis[triphenylphosphine]-palladium(II) + benzene + silver acetate/acetic acid 532
– di-μ-chlorodichlorobis[styrene]-palladium(II) + benzenes + acetic acid 524
– 1,1-dimethyl-π-allyl-nickel bromide + 1-bromo-2-methyl-2-alkenes 175 (2717)

- Metal-Arene Complexes
Synthesis
– diarenechromium(0) complexes from diarenechromium(I) halides by electrochemical reduction 385

- Metal Complexes of Non-Benzenoid Conjugated Unsaturated Cyclic Systems
see also: Ferrocenes
Synthesis
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt complexes from cyclopentadienecobalt-triphenylphosphine complex and alkynes 819 (3322)
– (carboxycyclopentadienyl)-tricarbonylmanganese 360
– [(2-chlorobenzoyl)-cyclopentadienyl]-tricarbonylmanganese 360
– cyclooctadiene-π-cyclooctatrienylcobalt 390
– cyclopentadienyldicarbonyliron-mercury complex 386
– cyclooctatetraenenickel(0) 389
– cyclooctatetraenyl-transition metal complexes by electrochemical reduction procedures 387
– cyclopentadienyl-dicarbonyl-triphenylplumbyliron 387
– cyclopentadienyl-dicarbonyl-(triphenylstannyl)-iron 387
– cyclopentadienyl-tricarbonyl-(triphenylplumbyl)-moiybdenum 387
– cyclopentadienyl-tricarbonyl-(triphenylstannyl)-molybdenum 387
– tetracarbonyl-(triphenylplumbyl)-manganese 387
– tetracarbonyl-(triphenylstannyl)-manganese 387
Reactions
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + carbon disulfide 819 (3322)
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + methyl isothiocyanate 819 (3322)
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + nitriles 819 (3322)
– [(2-chlorobenzoyl)-cyclopentadienyl]-tricarbonylmanganese + potassium *t*-butoxide 360
– cyclobutadienetricarbonyliron + dimethyl acetylenedicarboxylate + cerium(IV) ammonium nitrate 667
– cyclobutadienyltricarbonyliron + cerium(IV) ammonium nitrate 354
– cyclopentadiene-(triphenylphosphine)-cobalt + alkynes 819 (3322)
– cyclopentadienyldicarbonyliron salts, electrochemical reduction at a mercury cathode 386
– cyclopentadienyltricarbonylmanganese + 2-chlorobenzoyl chloride + aluminum chloride 360
– dienylcarbonyliron complexes + cerium(IV) ammonium nitrate 354

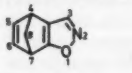
● 2,6-Methano-4-benzazonine



1*H*–

- 2,3,4,5,6,7-Hexahydro-1*H*-2,6-methano-4-benzazonines
Synthesis
- of the Ring Skeleton
– 4-alkyl-2,6-dialkoxycarbonyl-1,7-dioxo der. from 2,4-dialkoxycarbonyl-1,5-dioxo 2,3,4,5-tetrahydro-1*H*-benzocycloheptenes, formaldehyde, and alkylamines 725

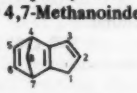
● 4,7-Methano-1,2-benzoxazole



4,7–Dihydro–

- 3a,4,5,6,7,7a-Hexahydro-4,7-methano-1,2-benzoxazoles
Synthesis
- of the Ring Skeleton
– 3-phenyl der. 158

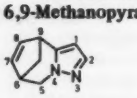
● 4,7-Methanoindene



4,7–Dihydro–1*H*–

- Octahydro-4,7-methanoindenes (Tricyclo[5.2.1.0^{2,6}]decanes)
Reactions
- Transformation of the Ring Skeleton
– – with hexafluoroantimonic acid 488

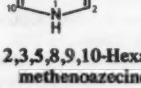
● 6,9-Methanopyrazolo[1,5-*a*]azepine



6,9–Dihydro–5*H*–

- 6,7,8,9-Tetrahydro-6,9-methano-5*H*-pyrazolo[1,5-*a*]azepines
Synthesis
- of the Ring Skeleton
– 5-oxo der. from 2-diazo-3-oxobicyclo[2,2.1]heptanes and activated alkynes 503 (3009)

● 3,8-Methenoazecine

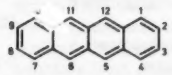


- 2,3,5,8,9,10-Hexahydro-3,8-methenoazecines
Synthesis
- of the Ring Skeleton
– – from 1-dimethylamino-3-phenylpropane by irradiation 821 (3330)

● Monosaccharides and Derivatives
- C_4-Monosaccharides
Aldoses and Ketoses
- Synthesis
– (4*S*)-L-threose-4-*d* 238 (2827)
- C_5-Monosaccharides
Alduloses
- Reactions
– 1,2-*O*-isopropylidene-5-deoxy-β-*threo*-pentofuranos-3-ulose + 2-lithio-1,3-dithiane 187 (2775)
O-Derivatives
-Synthesis
– methyl 2(or 3)-*O*-acetylpentofuranosides from methyl pentofuranosides and (1.) *N,N*-dimethylcarboxamide dimethyl acetals, (2.) acetic acid 187 (2774)
Glycosyl Halides
- Reactions
– furanosyl halides + 7-trimethylsiloxypteridines 700 (3220)
– *O*-protected 2-*O*-acetylpentofuranosyl bromides + bromomercury(II)- or silver dialkyl phosphites 700 (3219)
Methyl Glycosides
- Reactions
– methyl pentofuranosides + *N,N*-dimethylcarboxamide dimethyl acetals 187 (2774)
Miscellaneous Derivatives
- Synthesis
– 1,2-*O*-(1-dialkylphosphonoethylidene)-pentofuranoses 700 (3219)
– 1,2-*O*-isopropylidene-L-streptose 187 (2775)
- C_6-Monosaccharides
Anhydro Sugars (cyclic)
- Synthesis
– (1*S*)-1,5-anhydro-D-glucitol-1-*d* 238 (2827)
Dehydro-Sugars
- Synthesis
– *O*-protected 1-deoxy-1,2-didehydrohexopyranoses from *O*-protected hexopyranosyl halides and triethyl phosphite 700 (3221)
O-Derivatives
- Synthesis
– 6-*O*-acetyl-1,2-*O*-isopropylidene hexofuranose 187 (2774)
Glycosyl Halides
- Reactions
– 3-*O*-mesyl-tri-*O*-acetylhexofuranosyl bromides + bromomercury(II)- or silver dialkyl phosphites 700 (3219)
– *O*-protected hexopyranosyl halides + triethyl phosphite 700 (3221)
– tetra-*O*-acetylhexopyranosyl bromides + bromomercury(II)- or silver dialkyl phosphites 700 (3219)
– tetra-*O*-acetylhexopyranosyl bromides + silver dimethyl phosphite + oxygen 701 (3222)
Nitro Sugars
- Synthesis
– methyl 4,6-*O*-benzylidene-2,3-dideoxy-3β-nitrohexopyranosides 239 (2828)
- Reactions
– methyl 4,6-*O*-benzylidene-2,3-dideoxy-3-nitro-2-hexenopyranosides + sodium borohydride 239 (2828)
– methyl 4,6-*O*-benzylidene-2,3-dideoxy-3-nitro-2-hexenopyranosides + zinc/acetic acid 239 (2828)
Miscellaneous Derivatives
- Synthesis
– 1,2-*O*-(1-dialkylphosphonoethylidene)-hexofuranoses 700 (3219)
– 1,2-*O*-(1-dialkylphosphonoethylidene)-hexopyranoses 700 (3219)
– dimethyl tetra-*O*-acetylhexopyranosyl phosphates from tetra-*O*-acetylhexopyranosyl bromides and silver- or mercury(II) diethyl phosphite/oxygen 701 (3222)

– methyl 6-aminosulfonyl-6-deoxy-α-D-glucopyranosides from methyl 6-chlorosulfonyl-2,3,4-tri-*O*-acetyl-6-deoxy-α-D-glucopyranoside and amines 222
– methyl 4,6-*O*-benzylidene-2,3-dideoxy-3-oximinohexopyranosides 239 (2828)
– methyl 6-chlorosulfonyl-2,3,4-tri-*O*-acetyl-6-deoxy-α-D-glucopyranoside 222
Reactions
– glucose phenylosotriazole + cerium(IV) ammonium nitrate 348

● **Naphthacene**



- 5,12-Dihydronaphthacenes
Synthesis
- of the Ring Skeleton
– 6,11-dihydroxy-1-methoxynaphthacene-5,12-quinones from 2-ethoxycarbonyl-8-methoxy-1,4-naphthoquinones and phthalide anion 319 (2854)

● **Naphthalene**

- Naphthalenes
Synthesis
- from Like Ring Skeletons
– – from 1,4-dibromotetralins, on silica gel 317 (2846)
– aminonaphthalenes from naphthalene by radical amination 11
– dialkylaminonaphthalenes from naphthalenes and *N*-chlorodialkylamines 7
- of the Ring Skeleton
– 1,4-diphenylnaphthalene-2,3-dicarboxylic anhydrides from benzylidenediphenylmethylenesuccinic anhydrides 118 (2694)
– 1,2-diphenyl-5,6,7,8-tetramethylnaphthalenes from *trans*-3,4-bis[phenylethynyl]-tetramethylcyclobutene and alkynes 783
– octachloronaphthalene 680
– polymethylnaphthalenes from (2-hydroxy-4-oxoalkyl)-benzenes and polyphosphoric acid 620
Reactions
- Fusion of New Rings
– 1,4-diphenylnaphthalene-2,3-dicarboxylic anhydride, irradiation 118 (2694)
- Retention of the Ring Skeleton
– naphthalene + cerium(IV) ammonium nitrate 352

- 1,2-Dihydronaphthalenes
Reactions
- Fusion of New Rings
– 4-ethenyl-7-methoxy der. + 2,6-dimethyl-*p*-benzoquinone 117 (2690)

- 1,2,3,4-Tetrahydronaphthalenes (Tetralins)
Synthesis
- from Like Ring Skeletons
– 2-amino-5,6-dimethoxy-1-tetralone 116 (2685)
- of the Ring Skeleton
– 1,4-dibromotetralins from 1,2,3,4-tetrahydro-1,4-oxidonaphthalenes and dibromotriphenylphosphorane 317 (2846)
– tetralin-2,3-dicarboxylic acids and anhydrides from 1,2-bis[methylene]cyclohexadienes and maleic anhydride 416
Reactions
- Retention of the Ring Skeleton
– tetralin + cerium(IV) ammonium nitrate 351

- 1,4,8,8a-Tetrahydronaphthalenes
Synthesis
- of the Ring Skeleton
– 1,4-dioxo der. from *p*-benzoquinones, 2-alkenals, and ethoxymagnesium bromide 369 (2897)

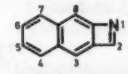
- 1,2,3,5,6,8a-Hexahydronaphthalenes
Synthesis
- from Like Ring Skeletons
– 4,7-dimethyl-1-isopropyl der. 367 (2888)

- 1,2,4a,5,6,8a-Hexahydronaphthalenes
Synthesis
- from Like Ring Skeletons
– 4,7-dimethyl-1-isopropyl der. 367 (2888)

- 1,2,3,4,5,6,7,8-Octahydronaphthalenes
Synthesis
- of the Ring Skeleton
– 7,8-dicarboxy-1-oxo der. from 1-(2-aminoethyl)-3-oxocyclohexenes and maleic anhydride 769

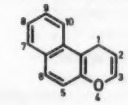
- Decahydronaphthalenes (Decalins)
Synthesis
- of the Ring Skeleton
– 3-alkoxycarbonyl-8a-hydroxy-2-oxo der. from 2-aminomethylcyclohexanones and alkyl acetoacetates 771

● **Naphtho[2,3-*b*]azete**



- 1,2-Dihydronaphtho[2,3-*b*]-azetes
Synthesis
- of the Ring Skeleton
– 2-oxo-1-phenyl der. 344

● **Naphtho[2,1-*b*]pyran**

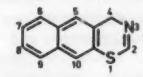


1H–

- 1*H*-Naphtho[2,1-*b*]pyrans
Synthesis
- of the Ring Skeleton
– – from 1-dialkylaminomethyl-2-naphthols and α*H*-ketones 771

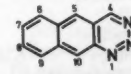
- 2,3-Dihydro-1*H*-naphtho[2,1-*b*]-pyrans
Synthesis
- of the Ring Skeleton
– 3-oxo der. from 1-dialkylaminomethyl-2-naphthols and alkanoic acid esters 771

● **Naphtho[2,3-*e*]-1,3-thiazine**



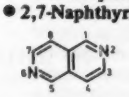
Synthesis
- of the Ring Skeleton
– 2-chloro-4-oxo der. 192

● **Naphtho[2,3-*d*]-1,2,3-triazine**



- 3,4-Dihydronaphtho[2,3-*d*]-1,2,3-triazines
Reactions
- Transformation of the Ring Skeleton
– 4-oxo-3-phenyl der., irradiation 344

● **2,7-Naphthyridine**



Synthesis
- from Like Ring Skeleton
– 4-carboxy-2,7-naphthyridine 46
– 2,7-naphthyridine 46

● **Nitrenes**
- Heterocyclic Nitrenes
Reactions
– 4,6-dimethyl-2-pyrimidylnitrene + *trans*-stilbene 135
– *N*-Nitrenes
Generation
– phthalimidonitrene 821 (3329)
Reactions
– phthalimidonitrene + 1,3-dimethoxybenzenes 821 (3329)

● **Nitric Acid Esters**
Synthesis
– 3-acetoxy-1-nitryloxy-1-phenylpropane 351
– *vic*-azidonitryloxyalkanes from alkenes, sodium azide, and cerium(IV) ammonium nitrate 354
– 1,3-diaryl-1,3-dinitryloxypropanes from 1,2-diarylcyclopropanes and cerium(IV) ammonium nitrate 351
– 1,3-dinitryloxy-1-phenylpropane 351

● **Nitrile Inimes**
Reactions
– – with phosphine imides 482
– benzonitrile phenylimine + azidodiphenylborane 636

● **Nitrile Oxides**
Synthesis (or Generation in situ)
– – from aldazine *N,N'*-bis-oxides (aldoxime nitronates) by thermolysis 157
Reactions
- Cyclization Reactions
– – with aldazine *N,N'*-bis-oxides (aldoxime nitronates) 157
– – with alkenes 158
– – with alkynes 158
– – with 5-phenyl-2,3-dihydro-1*H*-1,4-benzodiazepines 559 (3075)
– benzonitrile oxide + triphenylphosphine *N*-phenylimide 482

● **Nitriles**
- General
Synthesis
- from Heterocyclic Compounds
– – from 1,3,4-thiadiazoles and sodium/alcohols 807 (3269)
- from Like Carbon Skeletons
– – from aldoximes and methyl isocyanate 321 (2861)
– – from aldoximes and phosphoronitrile dichloride 809 (3276)
– – from aldoximes and trichloro-1,3,5-triazine 367 (2891)
– – from carboxamides and phosphonitrile dichloride 554 (3055)
- from Unlike Carbon Skeletons
– α-trimethylsiloxy-nitriles from aldehydes and cyanotrimethylsilane 814 (3298, 3299)
– α-trimethylsiloxy-nitriles from ketones and cyanotrimethylsilane 814 (3298, 3299)
Reactions
– – with acyl chlorides in the presence of hydrogen chloride 189
– – with carbonyl chloride 198
– – with hydrogen chloride 189
– – with malonyl chlorides 193, 194

– α-trimethylsiloxy-nitriles, α-metallation-alkylation 777
● **Nitrilium Salts**
Reactions
– nitrilium tetrafluoroborates + azide ion 235 (2811)
● **Nitro Compounds**
- ***gem*-Dinitro Compounds**
Synthesis
– 1-amino-2,2-dinitroalkanes from 2,2-dinitro-1-hydroxyalkanes and primary or secondary amines 732
– 1,1-dinitro-1-fluoroalkanes from dinitrofluoromethane, silver oxide, and alkyl halides 605
– 4,4-dinitro-4-fluoro-1-butene 605
Reactions
– dinitrofluoromethane + silver oxide 605
– dinitrofluoromethane + silver oxide + alkyl halides 605
– 2,2-dinitro-1-hydroxyalkanes + primary or secondary amines 732
- **Nitroalkanes**
Synthesis
– – from alkanoic anhydrides and nitric acid 57 (2613)
– *vic*-acetoxynitroalkanes from 1-nitroalkanes, aldehydes, and acetic anhydride 626 (3113)
– 1-amino-2-nitroalkanes from nitroalkanes, formaldehyde, and primary or secondary amines 732
– *vic*-fluoronitroalkanes from alkenes, hydrogen fluoride/pyridine, and nitronium tetrafluoroborate 785
– higher nitroalkanes from 1-nitroalkanes and aldehydes 626 (3113)
– 2-nitrocyclohexanone 686 (3163)
– 6-nitrohexanamide 627 (3115)
– nitromethylpentamethylbenzene 498 (2991)
Reactions
– – aminomethylation by Mannich reaction 732
– – with benzofuroxan + ammonia 374 (2920)
– – with lead(IV) acetate 576
– ethyl nitroacetate + aldehydes + titanium(IV) chloride/base 119 (2698)
– 2-nitrocyclohexanone + ammonia 627 (3115)
– 2-nitrocyclohexanone + 1,ω-diaminoalkanes 627 (3115)
– 2-nitrocyclohexanone + primary amines 627 (3115)
– 7-nitro-3-heptyne + butenone 401
– nitromethyl ketones + 2-acetoxy-1-alkenes + tosic acid 561 (2084)
- **Nitroalkenes Type C=C–NO_2**
Synthesis
– 1-amino-2-nitrocyclohexenes from 2-nitrocyclohexanone and primary amines 627 (3115)
– ethyl 2-nitro-2-alkenoates from ethyl nitroacetate and aldehydes 119 (2698)
– 1-nitro-3-phenylhydrazono-1-alkenes from aldehyde phenylhydrazones, sodium hydride, and 1-dimethylamino-2-nitro-1-alkenes 613
- **Nitroarenes**
Synthesis
– polymethylnitroarenes from polymethylarenes and methyl nitrate/nitromethane 488
Reactions
– – with diphenylacetylene + carbon monoxide + hexadecacarbonylhexacobalt 235 (2812)
– – with potassium fluoride 429 (2936)
– *o*-chloromitrobenzenes + alkylmercaptoacetates + base 696 (3204)
– 2,2'-dinitrobiphenyl + aldehydes + reducing agents 326 (2882)
– 2-nitroacetophenone phenylhydrazones + triethyl phosphite 363
– 2-nitroanilinoacetonitriles + base 695 (3202)
– 2-nitrobenzaldehyde hydrazones + triethyl phosphite 363
– nitrobenzene + diphenylacetylene + irradiation 333
– nitrobenzenes + dodecacarbonyltriiron 318 (2851)
– nitrobenzenes + *o*-phthaldialdehyde + carbon monoxide + hexadecacarbonylhexarhodium 323 (2871)
– 2-nitrobenzonitriles + alkyl mercaptoacetates + base 815 (3304), 818 (3318)
- ***C*-Nitro-Heteroarenes**
Synthesis
– 3-nitro-1,2-oxazoles from 1-bromo-2-alkynes and sodium nitrite 697 (3207)
– 3-nitropyridine 326 (2880)
Reactions
– – with potassium fluoride 429 (2936)
– 8-nitrotetrazolopyridines, thermolysis 136
- **Nitronic Acids (*aci*-Nitro Compounds)**
Synthesis
– disodium cyclohexene-3,5-dinitronates from 1,3-dinitrobenzenes and sodium borohydride 733
– magnesium cyclohexene-3,5-dinitronates from 1,3-dinitrobenzenes and Grignard reagents 733
Reactions
– 3,5-di-*aci*-nitrocyclohexenes + formaldehyde + primary or secondary amines 733
– ***N*-Nitro Compounds**
Synthesis
– *N*-alkoxymethyl-*N*-alkylnitramines from alkylchloromethylnitramines and sodium alkoxides 302
– *N*-alkoxymethyl-*N*-alkylnitramines from sodium alkylnitramides and chloromethoxyalkanes 302
– *N*-alkyl-*N*-alkylsulfonylmethylnitramines from *N*-alkyl-*N*-alkylthiomethylnitramines and phthalomonoperoxoic acid 303
– *N*-alkyl-*N*-alkylthiomethylnitramines from alkylchloromethylnitramines and sodium alkanethiolates 303
– *N*-alkyl-*N*-arylsulfonylmethylnitramines from *N*-alkyl-*N*-arylthiomethylnitramines and phthalomonoperoxoic acid 303
– *N*-alkyl-*N*-arylsulfonylmethylnitramines from alkylchloromethylnitramines and sodium arenethiolates 303
– alkyl-(dialkylaminomethyl)-nitramines from sodium alkylnitramides and chloromethyldialkylamines 676
– alkyl-(4-dimethylaminobenzyl)-nitramines from 4-dimethylamino-1-dimethylaminomethylbenzene and alkylnitramines 676
– alkyl-(3-indolylmethyl)-nitramines from 3-dimethylaminomethylindole and alkylnitramines 676
– alkyl-(morpholinomethyl)-nitramines from dimorpholinomethane and alkylnitramines 676
– *N*-(4-methoxybenzyl)-*N*-methylnitramine 302
– 1-nitropyrazole 294
Reactions
– *N*-alkyl-*N*-alkylthiomethylnitramines + phthalomonoperoxoic acid 303
– *N*-alkyl-*N*-arylthiomethylnitramines + phthalomonoperoxoic acid 303
– alkylchloromethylnitramines + sodium alkanethiolates 303
– alkylchloromethylnitramines + sodium alkoxides 302
– alkylchloromethylnitramines + sodium arenethiolates 303
– alkylnitramines + dimethylaminomethylarenes or -heteroarenes 676
– alkylnitramines + dimorpholinomethane 676
– 1,2-bis[nitramino]-ethane + formaldehyde + primary amines 736
– 1,3-bis[nitramino]-propane + formaldehyde + 1,ω-diaminoalkanes 736
– 1-nitropyrazole, thermal isomerization 294
– sodium alkylnitramides + alkyl chloromethyl ethers 302
– sodium alkylnitramides + chloromethyldialkylamines 676
– sodium methylnitramide + 4-methoxybenzyl chloride 302
● **Nitrones**
- **Aldehyde Nitrones**
Synthesis
– α-chloroaldehyde cyclohexylnitrones from α-chloro-aldehydes and cyclohexylhydroxylamine 552 (3046)
– heterocyclic-aldehyde *N*-(4-dimethylaminophenyl)-nitrones from *C*-methyl heterocyclic compounds via 1-methylpyridinium iodides 482
Reactions
– alkanal 1-cyanoalkylnitrones + benzenethiols 374 (2923)
– benzaldehyde 4-dimethylaminophenyl nitrones + hydrazoic acid 299
– benzaldehyde phenylnitrone + diphenylketene 333
– benzaldehyde phenylnitrone + phenyl styryl sulfones 373 (2917)
– benzaldehyde phenylnitrones + phenylethynylcopper 694 (3195)
– α-chloro-aldehyde cyclohexylnitrones + alkenes 500 (2997), 503 (3007)
– α-chloroaldonitrones + alkenes + (1.) silver tetrafluoroborate + (2.) potassium cyanide 550 (3038)
● **Nitroso Compounds**
- **Nitrosoalkanes**
Synthesis
– – from nitrosooxyalkanes by irradiation 404
– – from trialkylboranes and nitrosyl chloride 659
- **Nitrosoarenes**
Reactions
– – with diphenylketene 333
– nitrosobenzene + dichloroamine 106
- ***N*-Nitroso Compounds**
Synthesis
– *N*-(1-alkoxyalkyl)-*N*-alkyl-*N*-nitrosoamines from alkyl-

amines, aldehydes, alcohols, and nitrous acid 626 (3112)
– dialkylnitrosoamines from other dialkylnitrosamines by 1-lithiation and reaction with electrophiles 627 (3114)
– ethyl *N*-cyclopropyl-*N*-nitroso-carbamates from ethyl *N*-cyclopropylcarbamates and dinitrogen tetroxide 31
– ethyl *N*-nitroso-*N*-(1-tosylalkyl)-carbamates from ethyl *N*-(1-tosylalkyl)-carbamates and nitrosyl chloride 812 (3290)
– 3-nitrosohexahydro-1,3-oxazepines from aldehydes, 4-aminobutanol, and nitrous acid 633 (3145)
– 3-nitrosotetrahydro-1,3-oxazines from aldehydes, 3-aminopropanol, and nitrous acid 633 (3145)
– 3-nitrosotetrahydro-1,3-oxazoles from aldehydes, aminoethanol, and nitrous acid 633 (3145)

Reactions
– alkyl-(lithiomethyl)-nitrosamines + arenecarbonitriles 633 (3141)
– *N*-alkyl-*N*-nitrosotosylamides, photochemical fragmentation 59 (2620)
– methyl *N*-(1-hydroxycyclohexyl)-*N*-nitrosocarbamate + alkenes + base 803 (3250)
– 5-substituted 3-nitroso-2-oxo-1,3-oxazolidines + butylamine 799 (3234)

● Nitroxyls

Synthesis
– 4-oxoimidazolidine-1-oxyls from 4-oxoimidazolidines and hydrogen peroxide 502 (3004)

● Nucleosides and Derivatives

Synthesis
– 2'-*O*- and 3'-*O*-benzyladenosine from N^6,5'-*O*-ditrityladenosine and benzyl bromide/base 508 (3027)
– 8-furanosyl-7-oxo-7,8-dihydropteridines from 7-trimethylsiloxypteridines, furanosyl halides, and mercuric oxide/mercury(II) bromide 700 (3220)
– nucleoside-5'-amidophosphoric acid esters from 5'-azidonucleosides and phosphorous acid esters 507 (3026)
– N^6-substituted adenosines from *O*-silyl-protected guanosines and amines 121 (2707)
– 2'-*O*-tetrahydropyranyl-6'-*O*-trityloxyacetylnucleosides from 2'-*O*-tetrahydropyranylnucleosides and sodium trityloxyacetate 239 (2830)
– 8,2'-thioanhydro-8-mercapto-9-(β-D-arabinofuranosyl)-purine nucleosides from 8-bromo-9-(β-D-arabinofuranosyl)-purine nucleosides (2 steps) 240 (2831)

Reactions
– 5'-azidonucleosides + phosphorous acid esters 507 (3026)

● Nucleotides and Derivatives

Synthesis
– oligonucleotides from mononucleotide 2-phenylthioethyl esters and mono- or oligonucleotides 239 (2829)
– oligonucleotides from pyridinium nucleoside 5'-phosphates by a Merrifield synthesis in liquid phase 821 (3331)
– oligoribonucleotides from *O*-blocked ribonucleosides and 2,2,2-trichloroethyl phosphorodichloridate 188 (2776)

● Organoaluminum Compounds

- Dialkylalanes Type R_2AlH
– diisobutylalane + *n*-alkenols + titanium(IV) butoxide 625 (3107)

- Dialkylalanes Type R_2AlX

Synthesis
– 1,1'-bis[diethylalumino]-4,4'-bipyridyl 385

- Tetraorganoalanates

Synthesis
– potassium diethyl-(1,4-dihydronaphthalene-1,4-diyl)-alanate 386

Reactions
– potassium tetraethyl alanate, electrochemical reduction in the presence of naphthalene 386

- Trialkylalanes

Synthesis
– 3-diethylalumino-3-ethyl-2-trimethylsilylpentane 310
– n-diisobutylalumino-1-diisobutylaluminooxyalkanes from *n*-alkenols, diisobutylalane, and titanium(IV) butoxide 625 (3107)

Reactions
– n-diisobutylalumino-1-diisobutylaluminooxyalkanes + oxygen/acetic anhydride 625 (3107)
– triethylaluminum + 3-diethylboryl-2-trimethylsilyl-2-pentene 310
– trimethylalane + carboxylic acids 228 (2781)
– trimethylalane + ketones 228 (2781)
– trimethylalane + tertiary alcohols 228 (2781)

● Organobismuth Compounds

Synthesis
– triethylbismuthine 395

● Organocadmium Compounds

Reactions
– – with aldehydes in the presence of diisopropyl (+)-*O*,*O*-dimethyltartrate 433 (2949)
– – with ketones in the presence of diisopropyl *O*,*O*-dimethyltartrate 433 (2949)

● Organocopper Compounds

- 1-Alkenylcopper(I)

Reactions
– – with methyl 2-alkynoates 119 (2699)
– ethenylcopper + alkyl 2,4-pentadienoates 807 (3267)

- 2-Alkenylcopper(I)

Reactions
– – with methyl 2-alkynoates 119 (2699)

- Alkylcopper(I)

Reactions
– butylcopper + alkyl 2,4-pentadienoates 807 (3267)

- 1-Alkynylcopper(I)

Reactions
– phenylethynylcopper + benzaldehyde phenylnitrones 694 (3195)

- Arylcopper(I)

Reactions
– – with iodotrimethylsilylacetylene 549 (3034)
– pentafluorophenylcopper + 1-bromo-2-triethylsilylacetylene 318 (2847)
– polyhaloarylcopper + iodotrifluoroethylene 684 (3154)

- Heteroarylcopper(I)

Synthesis
– 2-furylcopper 561 (2083)

Reactions
– 2-furylcopper + haloarenes 561 (2083)
– 2-furylcopper + iodotrimethylsilylacetylene 549 (3034)
– tetrahalopyridylcopper + iodotrifluoroethylene 684 (3154)
– 2-thienylcopper + iodotrimethylsilylacetylene 549 (3034)

- Organocuprates

Synthesis
– lithium alkylcyanocuprates from copper(I) cyanide and alkyllithium 684 (3156)
– lithium bis[1-alkenyl]-cuprates from 1-bromo-1-alkenes, lithium, and bis[trimethyl phosphite]-copper(I) iodide 118 (2692)

Reactions
– lithium alkylcyanocuprate + 1-bromoadamantane 684 (3156)
– lithium alkylcyanocuprates + 3-oxocyclohexene 684 (3156)
– lithium bis[1-alkenyl]-cuprates + alkyl 2,4-pentadienoates 118 (2692)
– lithium bis[1-alkenyl]-cuprates + methyl 2-alkynoates 119 (2699)
– lithium bis[1,1-diphenylthioalkyl]-cuprates + 1-alkenyl ketones 434 (1954)
– lithium dialkylcuprates + acyl chlorides 178 (2730)
– lithium dialkylcuprates + 1-halo-1,2-alkadienes 175 (2718)

- Miscellaneous Organocopper(I) Compounds

Reactions
– cyclopentadienylcopper(I)-tributylphosphine + acyl chlorides 366 (2886)

● Organogermanium Compounds

Synthesis
– diphenylgermane 385
– triphenylgermane 385

Reactions
– chlorotriphenylgermane, electrochemical reduction 385
– dichlorodiphenylgermane, electrochemical reduction 385

● Organolead Compounds

Synthesis
– hexaethyldiplumbane 386
– tetraethylplumbane 383, 394, 395
– tetrakis[3-nitrilopropyl]-plumbane 383

Reactions
– triethyllead chloride, electrochemical reduction 386

● Organolithium Compounds

- 1-Alkenyllithium

Reactions

- C-C Coupling Reactions -
– – with 2-methoxyacrolein 104

- Other Reactions
– 1-chloro-2,2-diarylethenyllithium + triphenylborane 644

- 2-Alkenyllithium

Synthesis
– 1-lithio-5,5-dimethyl-2-hexene 559 (3073)

Reactions

- C-C Coupling Reactions
– indenyllithium + alkyl halides 159
– indenyllithium + dimethyl sulfate 159

- Alkyllithium

Synthesis
– *N*-alkyl-*N*-(1-lithioalkyl)-*N*-nitrosoamines from dialkylnitrosamines and lithium diisopropylamide 627 (3114)

– *gem*-bromolithioalkanes *in situ* from *gem*-dibromoalkanes and butyllithium 182 (2751)
– trichloromethyllithium 317 (2845)
Reactions
- *C-C Coupling Reactions*
– – with isocyanates 678
– *N*-alkyl-*N*-(1-lithioalkyl)-*N*-nitrosoamines + electrophilic carbon compounds 627 (3114)
– alkyl-(lithiomethyl)-nitrosamines + arenecarbonitriles 633 (3141)
– *gem*-bromolithioalkanes *in situ* + aldehydes 182 (2751)
– *gem*-bromolithioalkanes *in situ* + ketones 182 (2751)
– *t*-butyllithium + butadiene 559 (3073)
– dichloromethyllithium + aldehydes 553 (3049)
– dichloromethyllithium + ketones 553 (3049)
– 1-lithioalkyl isocyanides + oxiranes 699 (3215)
– 2-lithiomethylthio-4,5-dihydro-1,3-thiazole + alkyl halides 228 (2782)
– trichloromethyllithium + *N,N*-dialkyl-*N*-halomethylamines 317 (2845)
- *Other Reactions*
– dichloromethyllithium + dialkyl ketones 403
– dichloromethyllithium + triphenylborane 644
– isocyanomethyllithium + tosyl fluoride 62 (2634)
- 1-Alkynyllithium
Synthesis
– dialkylaminoethynyllithium from dialkylaminotrichloroethylenes and butyllithium 402
Reactions
-*C-C Coupling Reactions*
– – with 2-(2-bromoethyl)-2-methyl-1,3-dioxolane 400
– – with trialkylboranes 803 (3249)
– – with triphenylborane 803 (3249)
– lithium triethylsilylacetylenides + hexafluorobenzene 318 (2847)
– 1-propynyllithium + 2-methoxyacrolein 104
- 2-Alkynyllithium
Reactions
- *C-C Coupling Reactions*
– 2-propynyllithium + 2-methoxyacrolein 104
- Aryllithium
Reactions
- *C-C Coupling Reactions*
– – with isocyanates 678
– – with pentachlorobenzonitrile 555 (3058)
- Heteroaryllithium
Reactions
– 2-lithiofuran + trialkylboranes 659
- α-Lithiocarboxylic Acid Derivatives
Synthesis
– ethyl α-lithiocarboxylates from ethyl α-bromocarboxylates and lithium bis[trimethylsilyl]-amide 234 (2807)
– ethyl trimethylsilyl lithiomalonate 537
Reactions
- *C-C Coupling Reactions*
– ethyl α-lithiocarboxylates + aldehydes 234 (2807)
– ethyl α-lithiocarboxylates + ketones 234 (2870)
– ethyl trimethylsilyl lithiomalonate + 2-alkenoyl chlorides 537
– ethyl trimethylsilyl lithiomalonate + 3-ethoxypropanoyl chloride 537
– lithium α-lithiocarboxylates + *O*-alkylhydroxylamines 566 (3100)
- Non-Aromatic *C*-Lithio-Heterocyclic Compounds
Reactions
- *C-C Coupling Reactions*
– 2-(2,2-dimethoxyethyl)-2-lithio-1,3-dithian + ketones 696 (3205)
– 2-(2,2-dimethoxyethyl)-2-lithio-1,3-dithian + oxiranes 696 (3205)
– 2-lithio-2-trimethylsilyl-1,3-dithian + aldehydes or ketones 692 (3187)
- *Other Reactions*
– 2-carbo-substituted 2-lithio-1,3-dithianes + dimethyl disulfide 630 (3128)
- Miscelaneous Types
Reactions
- *C-C Coupling Reactions*
– lithio der. of methyl methylthiomethyl sulfoxide + aromatic aldehydes or ketones 177 (2728)
– lithiotrialkylthiomethanes + iodine 322 (2866)
– lithiotriarylthiomethanes + iodine 322 (2866)
● Organomagnesium Compounds
- General, Type R-MgHal
Reactions
- *C-C Coupling Reactions*
– – with aminomethyl phenyl sulfides 765
– – with carbon disulfide 557 (3065)
– – with 2-carbo-substituted 5,6-dihydro-4*H*-1,3-oxazines + methyl iodide 805 (3261)
– – with 2-oxoalkanenitriles 180 (2742)
- 1-Alkenylmagnesium Halides
Reactions
- *C-C Coupling Reactions*
– ethenylmagnesium chloride + carboxylic acids + copper(I) chloride 230 (2790)
– ethenylmagnesium chloride + methyl carboxylates + copper(I) chloride 230 (2790)
– styrylmagnesium bromide + thionyl chloride 550 (3037)
- 3-Alkenylmagnesium Halides
Reactions
- *C-C Coupling Reactions*
– 3-hexenylmagnesium bromide + acetic anhydride 398
- Alkylmagnesium Halides
Reactions
- *C-C Coupling Reactions*
– benzylmagnesium chlorides + 3-methylpentanedione 620
– 2-(1,3-dioxolan-2-yl)-ethylmagnesium bromides + 2-acylthiophenes 818 (3314)
– 2-methylbutylmagnesium bromide + 3-bromopropyne 31
– methylmagnesium iodide + 5-chloro-3-alken-1-ynes 56 (2608)
- *Other Reactions*
– methylmagnesium bromide + ethyl α-acetylacetoacetate 60 (2626)
- 1-Alkynylmagnesium Halides
Reactions
- *C-C Coupling Reactions*
– 1-alkynylmagnesium bromides + butoxymethyldialkylamines 705
– 1-alkynylmagnesium bromides + *N,N*-dialkyl-*N'*-phenylisourea chlorides 67 (2656)
– 2-arylethynylmagnesium bromides + thionyl chloride 550 (3037)
- Miscellaneous Compounds of the Type R-MgX
Synthesis
– magnesium bromide 3-chloromagnesiopropoxide 176 (2724)
● Organomercury Compounds
- Type R-Hg-R
Synthesis
– bis[3-nitrilopropyl]-mercury 383
– dibenzylmercury compounds from benzyl bromides by electochemical reduction on a mercury cathode 384
– di-*sec*-butylmercury 383
– diphenylmercury 386
– phenyl-(trifluoromethyl)-mercury 438 (2973)
Reactions
– diarylmercury + carbon monoxide + palladium chloride 522
– diarylmercury + carbon monoxide + water + palladium chloride 522
– (1,1-dibromo-2-oxo-2-piperidinoethyl)-phenylmercury, thermolysis 346
- Type R-HgX
Synthesis
– 1-alkenylmercury(II) salts from alkynes via hydroboration and acetoxymercuration 438 (2972)
– 3-chloromercurio-4-methoxy-2-pentene 35
– 2-dialkylaminoalkylmercury(II) chlorides from activated 1-alkenes and dialkylamine-mercury(II) chloride complex 814 (3300)
– 6-hydroxy-9-oxabicyclo-[3.3.1]non-2-ylmercury iodide 376 (2931)
Reactions
– arylmercuric chlorides + carbon monoxide + alcohols + palladium chloride 522
– arylmercuric chlorides + carbon monoxide + palladium chloride 522
– arylmercuric chlorides + carbon monoxide + water + palladium chloride 522
– arylmercuric halides + 1-alkenes + lithium tetrachloropalladate 533
● Organosilicon Compounds
see: Silanes
● Organosilver Compounds
Synthesis
– silver dinitrofluoromethanide 605
Reactions
– silver dinitrofluoromethanide + alkyl halides 605
● Organosodium Compounds
Synthesis
– sodium ethoxyacetylenide 318 (2850)
Reactions
- *C-C Coupling Reactions*
– disodioacetylacetone + 2-alkyl-1,3-dioxolanes 685 (3162)
– sodium cyclopentadienide + acetoxytropylium tetrafluoroborate 55 (2604)
● Organothallium Compounds
Synthesis
– arylthallium(III) bis-trifluoroacetates from arenes and thallium(III) acetate 231 (2793)
– 1-(1-methoxyalkyl)-1-alkenylthallium(III) acetates from allenes, thallium(III) acetate, and methanol 372 (2914)

Reactions
– arylthallium(III) bis-trifluoroacetates + peroxytrifluoroacetic acid 231 (2793)
– arylthallium(III) salts + copper(I)- or copper(II) cyanide 232 (2796)

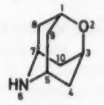
● **Organotin Compounds**
Synthesis
– hexaalkyldistannanes from chlorotrialkylstannanes by electrochemical reduction 386
– hexaaryldistannnanes from chlorotriarylstannanes by electrochemical reduction 386
– tetrakis[3-nitrilopropyl]stannane 383
Reactions
– chlorotrialkylstannanes, electrochemical reduction 386
– chlorotriarylstannanes, electrochemical reduction 386
– dialkoxydibutyltin + carbon disulfide 233 (2801)
– tetraphenylstannane + carbon monoxide + water + palladium chloride 522

● **Organozinc Compounds**
- Alkylzinc Halides
Reactions
– 1-cyanoalkylzinc bromides + carboxylic anhydrides 120 (2700)
- α-Halozincocarboxylic Acid Derivatives
Reactions
– alkyl 2-bromozincoalkanoates + *N*-arylalkanimines 566 (3101)

● **Orthocarbonic Acid Esters**
- Tetraalkyl Orthocarbonates
Synthesis
– – from carbon disulfide and dialkoxydibutyltin 233 (2801)
– – from thallium(I) alkoxides and carbon disulfide 810 (3281)
– spirocyclic tetraalkyl orthocarbonates from dithallium(I) glycolates and carbon disulfide 810 (3281)

● **Orthocarboxylic Acid Esters**
Synthesis
– cyclic orthoacetates from diols and trialkyl orthoacetates 689 (3175)
– trialkyl orthocarboxylates from *vic*-diketone bis[dialkyl acetals] by anodic oxidation 501 (2999)
– triethyl 2-bromoorthopropanoate 207
– triethyl 2-bromoorthopropenoate 207
– triethyl 2,3-dibromoorthopropanoate 207
– triethyl ortho-2-alkenoates from triethyl 2-bromoorthoalkanoates and potassium *t*-butoxide 207
– triethyl orthopropynoate 207
– tris[1-alkenyl] orthocarboxylates from tris[2-chloroalkyl] orthocarboxylates and base 808 (3271)
– tris[2-chloroalkyl] orthocarboxylates from trimethyl orthocarboxylates and 2-chloroalkanols 808 (3271)
Reactions
– 4-chlorophenyl dialkyl orthoformates + sodium hydride 321 (2860)
– cyclic orthoacetates, chlorinative cleavage with trityl chloride 689 (3175)
– triethyl 2-bromoorthoalkanoates + potassium *t*-butoxide 207
– triethyl orthoalkanoates + bromine + pyridine 207
– triethyl orthocarboxylates + 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene 355

● **2-Oxa-6-azaadamantanes**



Synthesis
- of the Ring Skeleton
– 4,8-dibromo-6-tosyl der. 699 (3217)

● **2-Oxa-7-azabicyclo[3.2.0]-heptane**

Synthesis
- of the Ring Skeleton
– 3,6-dioxo-1-methyl-7-phenylsulfonyl der. 342

● **3-Oxa-7-azabicyclo[3.3.1]nonane**

Synthesis
- of the Ring Skeleton
– 1,5-dialkoxycarbonyl-9-oxo der. from 3,5-dialkoxycarbonyl-4-oxotetrahydropyrans, formaldehyde, and primary amines 725

● **3-Oxabicyclo[3.1.0]hexane**

Synthesis
- of the Ring Skeletons
– – from 2-alkoxymethyl-1,1-dibromocyclopropanes and methyllithium 185 (2762)

● **9-Oxabicyclo[3.3.1]nonane**

Synthesis
- of the Ring Skeleton
– 2-hydroxy-6-iodo der. 376 (2931)

● **9-Oxabicyclo[6.1.0]nonane**

- 9-Oxabicyclo[6.1.0]non-4-enes
Reactions
- Transformation of the Ring Skeleton
– – with (1.) mercury(II) acetate, (2.) potassium iodide 376 (2931)

● **2-Oxabicyclo[3.3.0]octane**

- 2-Oxabicyclo[3.3.0]oct-6-enes
Synthesis
- from Like Ring Skeletons
– 3-hydroxy der. 408
- of the Ring Skeleton
– 3-oxo der. 408

● **1,2-Oxaborin**

2H–

- 2*H*-1,2-Oxaborins
Synthesis
- of the Ring Skeleton
– 2-ethyl-4,6-diphenyl der. 674
- 3,6-Dihydro-2*H*-1,2-oxaborins
Synthesis
- of the Ring Skeleton
– 2,3,3-trialkyl der. from 2-lithiofuran and trialkylboranes 659

● **1,2-Oxaborole**

- 2,3-Dihydro-1,2-oxaboroles
Synthesis
- of the Ring Skeleton
– – from 1-alkynyllithium, trialkylboranes, and acyl chlorides 805 (3257)
– – from dialkyl-(3-oxo-1-alkenyl)-boranes 651

● **1,3,5-Oxadiazine**

2H–

- 1,3,5-Oxadiazinium Salts
Synthesis
- of the Ring Skeleton
– 6-aryl-2,4-bis[dialkylamino]-1,3,5-oxadiazinium chlorides from dialkylcyanamides and aroyl chlorides 202
Reactions
- Transformation of the Ring Skeleton
– 2-aryl-4,6-bis[dialkylamino]-1,3,5-oxadiazinium chlorides + ammonia 202
- Tetrahydro-1,3,5-oxadiazines
Synthesis
- from Like Ring Skeletons
– 3-alkyl-5-alkylthiomethyl-4-oxo der. from the corresponding 5-alkoxymethyl der. and alkylmercaptans 247
- of the Ring Skeleton
– 3,5-bis[alkoxymethyl]-4-oxo der. from urea, formaldehyde, and alcohols 246
– 4-oxo der. from *N,N'*-bis[hydroxymethyl]ureas and acid 245
– 4-oxo-2,3,5,6-tetraalkyl der. from *N,N'*-dialkylureas and aliphatic aldehydes 246
– 4-oxo-2,3,5-trialkyl der. from *N,N'*-dialkylureas, formaldehyde, and higher alkanals 246
Reactions
- Retention of the Ring Skeleton
– 3-alkoxy-5-alkyl-4-oxo der. + alkylmercaptans + acid 247
– 3,5-bis[alkoxymethyl]-4-oxo der. + triphenylphosphine + hydrogen bromide 248
- Ring-Cleavage Reactions
– 3,5-dialkyl-4-oxo der. + thiourea + hydrogen chloride 248
– 3,5-dialkyl-4-oxo der. + triphenylphosphine + hydrogen chloride (+ methanol) 248
- Transformation of the Ring Skeleton
– 3,5-dialkyl-4-oxo der. + alkylamines 247
– 3,5-dialkyl-4-oxo der. + *N,N'*-dialkylureas 247
– 3,5-dialkyl-4-oxo der. + hydrochloric acid 247
– 4-oxo-2,3,5-trialkyl der. + acid 249

● **1,2,4-Oxadiazole**

- 1,2,4-Oxadiazoles
Synthesis
- of the Ring Skeleton
– – from aldazine N,N'-bis-oxides (aldoxime nitronates) by thermolysis 157
– 3-alkoxycarbonyl der. from acylaminoacetonitriles, alkyl nitrite, acid, and alcohols 373 (2919)
– 3-aminocarbonyl der. from acylaminoacetonitriles, alkyl nitrites, and acid 373 (2918)
– 4-oxides from aldazine N,N'-bis-oxides (aldoxime nitronates) by thermolysis 157

- 4,5-Dihydro-1,2,4-oxadiazoles
Synthesis
- of the Ring Skeleton
– 3,4-diphenyl-5-phenylimino der. 482
– 3-phenyl-5-sulfonylimino der. from benzohydroximic acid amides and *N*-dichloromethylene-sulfonamides 323 (2870)

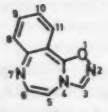
● **1,2,5-Oxadiazole**
see: Furazan

● **1,3,4-Oxadiazole**

- 1,3,4-Oxadiazolium Salts
Reactions
- Transformation of the Ring Skeleton
– – with cyanamide/base 66 (2652)

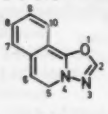
- 2,5-Dihydro-1,3,4-oxadiazoles
Synthesis
- of the Ring Skeleton
– 5,5-dialkyl-2-oxo der. from dialkyl ketone semicarbazones and lead(IV) acetate 322 (2868)

● **1,2,4-Oxadiazolo[4,5-*d*][1,4]-benzodiazepine**



- 5,6,7,11b-Tetrahydro-1,2,4-oxadiazolo[4,5-*d*][1,4]benzodiazepines
Synthesis
- of the Ring Skeleton
– 11b-phenyl der. from 5-phenyl-2,3-dihydro-1*H*-1,4-benzodiazepines and nitrile oxide *in situ* 559 (3075)

● **[1,3,4]Oxadiazolo[2,3-*a*]isoquinoline**



5*H*–

- 2,3,6,10b-Tetrahydro-5*H*-[1,3,4]oxadiazolo-[2,3-*a*]isoquinolines
Synthesis
- of the Ring Skeleton
– 3-phenyl der. from 2-phenylimino-3,4-dihydroisoquinolinium ylids and aldehydes or ketones 480

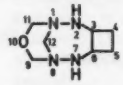
● **12-Oxapentacyclo[4.4.3.0^{1,6}.0^{2,5}.0^{7,10}]tridecane**

- 12-Oxapentacyclo[4.4.3.0^{1,6}.0^{2,5}.0^{7,10}]-trideca-3,8-dienes
Synthesis
- of the Ring Skeleton
– – from a bis[hydroxymethyl]-tetracyclo precursor by cyclodehydration 667

● **1,3-Oxaphosphole**

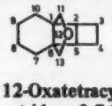
- 1,3-Oxaphospholanes
Synthesis
- of the Ring Skeleton
– – from 2-hydroxyalkylphosphines and aldehydes or ketones 120 (2703)
– 3-phenyl der. from 2-phenylphosphinoalkanoic acids and aldehydes or ketones 183 (2755)

● **10-Oxa-1,2,7,8-tetraazatricyclo[6.3.1.0^{3,6}]dodecane**



- 10-Oxa-1,2,7,8-tetraazatricyclo[6.3.1.0^{3,6}]dodec-3(6)-enes
Synthesis
- of the Ring Skeleton
– 2,7-dimethyl-4,5-dioxo der. 355

● **12-Oxatetracyclo[4.4.3.0^{1,6}.0^{2,5}]-tridecane**



- 12-Oxatetracyclo[4.4.3.0^{1,6}.0^{2,5}]-trideca-3,7,9-trienes
Synthesis
- of the Ring Skeleton
– – from a pentacyclo precursor 667

● **1,6,2-Oxathiaborepin**

- Tetrahydro-1,6,2-oxathiaborepins
Synthesis
- of the Ring Skeleton
– – from 2-alkyl-1,2-thiaborolanes and aldehydes or ketones 656

● **1,4,2-Oxathiazole**

- 1,4,2-Oxathiazoles
Synthesis
- of the Ring Skeleton
– 3-phenyl-5-sulfonylimino der. from benzothiohydroximic acid and *N*-dichloromethylene-sulfonamides 323 (2870)

- Dihydro-1,4,2-oxathiazoles
Synthesis
- of the Ring Skeleton
– cycloalkane⟨spiro-3⟩-2-methyl-dihydro-1,4,2-oxathiazole-⟨5-spiro⟩cycloalkanes from cycloalkanones, hydrogen sulfide, and methylhydroxylamine 561 (3082)

● **1,3-Oxathiole**

- 1,3-Oxathiolanes
Synthesis
- of the Ring Skeleton
– 4-alkoxycarbonyl-2-amino-carbonylimino der. from aldehydes and alkyl thiocyanatoacetates 373 (2916)
– 5-oxo-2-sulfonylimino der. from mercaptoacetic acid and *N*-dichloromethylene-sulfonamides 323 (2870)

● **2-Oxatricyclo[4.3.1.1^{4,8}]-undecane**

Synthesis
- of the Ring Skeleton
– 3-oxo der. 348

● **1,3,2-Oxazaborin**

2*H*– 4*H*–

-2,3,3,4-Tetrahydro-$N^{\oplus}$,$B^{\ominus}$-2*H*-1,3,2-oxaborins
Synthesis
- of the Ring Skeleton
– 4-oxo-2,2,3,3,6-pentamethyl der. 638

● **1,4,2-Oxazaborole**

- 2,3-Dihydro-$N^{\oplus}$,$B^{\ominus}$-1,4,2-oxazaboroles
Synthesis
- of the Ring Skeleton
– 2-cyano der. from acyl chlorides and potassium cyanotrialkylboranates 652

● **1,3-Oxazepine**

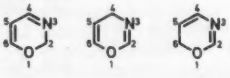
- Hexahydro-1,3-oxazepines
Synthesis
- of the Ring Skeleton
– 3 nitroso der. from aldehydes and 4-aminobutanol 633 (3145)

● **1,2-Oxazete**

2*H*–

- 1,2-Oxazetidines
Synthesis
- of the Ring Skeleton
– 2-aryl-3,3-diphenyl-4-oxo der. from diphenylketene and nitroso-arenes 333
– 2-aryl-4,4-diphenyl-3-oxo der. from diphenylketene and nitrosoarenes 333
Reactions
- Ring-Cleavage Reactions
– 2-aryl-3,3-diphenyl-4-oxo der., thermolysis 333

● **1,3-Oxazine**



2*H*– 4*H*– 6*H*–

- 4*H*-1,3-Oxazines
Synthesis
- of the Ring Skeleton
– 5-benzyl-6-chloro-4-oxo-2-phenyl- der. from benzylmalonyl chloride and benzonitriles 193
- 6*H*-1,3-Oxazines
Synthesis
- of the Ring Skeleton
– 4,5-diphenyl-6-oxo der. from 1-(carbonylimino)-pyridinium ylids and diphenylcyclopropenone 480
- 3,4-Dihydro-2*H*-1,3-oxazines
Synthesis
- of the Ring Skeleton
– 5-benzoyl-4-oxo-2,3,6-triphenyl der. 679
- 5,6-Dihydro-4*H*-1,3-oxazines
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- of the Ring Skeleton
– – from 3-hydroxyalkyl isocyanides 699 (3215)
– 6-oxo-4-phenyl der. from benzaldehyde *N,N'*-diacyl-aminals and carboxylic anhydrides 40
Reactions
- Fusion of New Rings
– 2-substituted 4,4,6-trimethyl der. + aminoacetyl chlorides + triethylamine 336
- Retention of the Ring Skeleton
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- Tetrahydro-1,3-Oxazines
Synthesis
- of the Ring Skeleton
– 2,6-dioxo der. from 3-ureido-propanoic acids, thermally 279
– 3-nitroso der. from aldehydes, 3-aminopropanol, and nitrous acid 633 (3145)
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– 2-oxo der. from alkyl 3-hydroxypropyl carbamates, thermally 279
– 2-oxo der. from 3-hydroxy-propylureas, thermally 279
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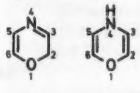
● **1,4-Oxazine**



2*H*– 4*H*–

- 3,4-Dihydro-2*H*-1,4-oxazines
Synthesis
- of the Ring Skeleton
– 4-aryl-6-(3-nitrophenyl)-3-oxo der. from *N*-aryl-*N*-(3-nitrophenacyl)-haloacetamides and triethylamine 339
- Tetrahydro-1,4-oxazinium Salts
Synthesis
- of the Ring Skeleton
– 3-benzyl-3-methyl-2-oxo der. from 2-(1,3-dioxan-5-yl)-2-methyl-3-phenylpropanenitriles 70 (2667)
Reactions
- Ring-Cleavage Reactions
– 3-benzyl-5-hydroxymethyl-2-oxo-6-phenyl der. + oxygen/Raney nickel 70 (2667)

● **Oxaziridine**

- Oxaziridines
Reactions
- Ring-Cleavage Reactions
– 1-methyloxaziridine(2-spiro)-cyclohexane + *N*-heteroarenes + iron(II) sulfate/water 12

● **1,2-Oxazole**

- 1,2-Oxazoles
Synthesis
- of the Ring Skeleton
– – from aldazine *N,N'*-bis-oxides (aldoxime nitronates) and alkynes 158
– 3-acyl-1,2-oxazoles from nitro-methyl ketones and 2-acetoxy-1-alkenes 561 (2084)
– 3-nitro-1,2-oxazoles from 1-bromo-2-alkynes and sodium nitrate 697 (3207)
Reactions
- Transformation of the Ring Skeleton
– – with diphenylcyclopropenone 820 (3323)
- 4,5-Dihydro-1,2-oxazoles
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- of the Ring Skeleton
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– 5-oxo der., aminomethylation by Mannich reaction 727
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Synthesis
- of the Ring Skeleton
– 5-phenylsulfonyl-2,3,4-triphenyl der. from benzaldehyde phenyl-nitrone and phenyl styryl sulfones 373 (2917)

● **1,3-Oxazole**

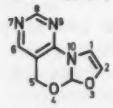
- 1,3-Oxazoles
Synthesis
- from Like Ring Skeletons
– 2-amino-4,5-diphenyl der. 695 (3200)
- of the Ring Skeleton
– 2,5-diphenyl der. from *N*-phenacylbenzamides and hydrogen fluoride 817 (3312)
– 4-methoxycarbonyl-5-phenyl der. from benzoyl chlorides and methyl isocyanoacetate 231 (2792)
Reactions
- Ring-Cleavage Reactions
– 4-methoxycarbonyl-5-phenyl der. + hydrochloric acid 231 (2792)
- Transformation of the Ring Skeleton
– 2-amino-4,5-diphenyl der. + potassium hydroxide 695 (3200)
- 1,3-Oxazolium Betaines
Synthesis
– 5-acylimino-3-amino-1,3-oxazolium betaines from α-hydrazinonitriles, acetic anhydride, and carboxylic anhydrides 766
– 2,4-diphenyl-1,3-oxazolium-5-oxides from benzoylamino-phenylacetic acids and acetic anhydride 470
Reactions
– 2,4-diphenly-3-methyl-1,3-oxazolium-5-oxide + 2-alkoxycarbonyl-3-phenylbicyclo[2.2.0]-hexanes 376 (2932)
– 2,4-diphenyl-5-oxo-1,3-oxazolium betaines + *N*-phenyl-phenylmethanimine 345
- 2,3-Dihydro-1,3-oxazoles
Synthesis
- from Like Ring Skeletons
– 4,5-diphenyl-2-oxo der. 695 (3200)
- of the Ring Skeleton
– 3-alkyl-4,5-diphenyl-2-oxo der. from 4,5-diphenyl-2-oxo-1,3-dioxole and alkylamines 240 (2833)
Reactions
- Ring-Cleavage Reactions
– 3-alkyl-4,5-diphenyl-2-oxo der., catalytic hydrogenation 240 (2833)
– 3-alkyl-4,5-diphenyl-2-oxo der. + sodium/ammonia 240 (2833)
- 4,5-Dihydro-1,3-oxazoles
Synthesis
- of the Ring Skeleton
– – from *N*-(2-hydroxyalkyl)-carboxamides and zinc acetate 183 (2754)
– 4-alkoxycarbonyl-5-phenyl der. from benzaldehydes and alkyl 2-isocyanoalkanoates 701 (3223)
– 2-amino-5-cyano-4,5-diphenyl der. from benzaldehydes, α-hydroxyphenylacetonitrile, and cyanamide 695 (3200)
– 2-(1-benzylaminoalkyl)-5-oxo-4,5-dihydro-1,3-oxazole-(4-spiro)cycloalkanes from 1-isocyanocycloalkane-carboxylic acids and *N*-benzyl-alkanimines 633 (3144)
Reactions
- Ring-Cleavage Reactions
– 4-alkylidene-5-oxo-2-phenyl der. + oxygen/triethylamine 231 (2795)
– 4-alkylidene-2-phenyl der. (azlactones) + hydrogen + ammonia + Raney nickel 629 (3125)
– 5-oxo-2-phenyl der. + enamines 60 (2625)
- Transformation of the Ring Skeleton
– 5-oxo-2-phenyl der. + formaldehyde 792
- Tetrahydro-1,3-oxazoles
Synthesis
- of the Ring Skeleton
– – from 2-hydroxyalkanamides and lead(IV) acetate 818 (3316)
– 3-alkyl-4,5-diphenyl-4-hydroxy-2-oxo der. from 4,5-diphenyl-2-oxo-1,3-dioxole and alkylamines 240 (2833)
– 2-alkylimino-4-alkylidene der. from α-hydroxyalkynes and carbodiimides 818 (3315)
– 3-nitroso der. from aldehydes, aminoethanol, and nitrous acid 633 (3145)
– 2-oxo der. from 3-hydroxy-alkanamides and lead(IV) acetate 818 (3316)
– 2-thiono der. from alkyl isothiocyanates and aldehydes or ketones 375 (2926)
Reactions
- Retention of the Ring Skeleton

– 4-oxo-2-thiono der., *N*-amino-methylation by Mannich reaction 739
- Ring-Cleavage Reactions
– 2,5-dioxo der. + amino-acids or peptides 241 (2837)
– 5-substituted 3-nitroso-2-oxo der. + butylamine 799 (3234)

● 1,2-Oxazolo[5,4-*d*]pyrimidine

- 3a,4,5,6,7,7a-Hexahydro-1,2-oxazolo-[5,4-*d*]pyrimidines
Synthesis
- of the Ring Skeleton
– 6-oxo der. from 5-acetyl-2-oxo-1,2,3,4-tetrahydropyrimi-dines and hydroxylamine 290

● 1,3-Oxazolo[2,3-*b*]pyrimido-[4,5-*d*][1,3]oxazine

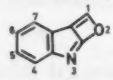


- 2,3-Dihydro-3a*H*-[1,3]oxazolo-[2,3-*b*]pyrimido[4,5-*d*][1,3]-oxazines
Synthesis
- of the Ring Skeleton
– 5-oxo-8-phenyl der. from 4-(2-hydroxyalkylamino)-2-phenylpyrimidine-5-carboxylic acids and acetic anhydride 633 (3143)

● Oxete

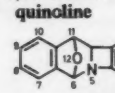
- Oxetanes
Reactions
- Transformation of the Ring Skeleton
– 2,3-bis[alkylimino]-oxetanes + 2-haloalkanoic acids 340

● Oxeto[2,3-*b*]indole



- 1,2a,3,7b-Tetrahydrooxeto[2,3-*b*]indoles
Synthesis
- of the Ring Skeleton
– 4-acyl-1-phenyl der. from 1-acylindoles and benzoic acid der. or benzophenone 694 (3194)

● 6,11-Oxidobenzazeto[1,2-*b*]iso-quinoline



6,11-Dihydro-11a*H*-

- 6,11-Dihydro-11a*H*-6,11-oxido-benzazeto [1,2-*b*]isoquinolines
Synthesis
- of the Ring Skeleton
– 6,11,11a-triphenyl der. 694 (3196)

● 1,4-Oxidonaphthalene

1,4-Dihydro-

- 1,2,3,4-Tetrahydro-1,4-oxido-naphtalenes
Reactions
- Ring-Cleavage Reactions
– – with dibromotriphenyl-phosphorane 317 (2846)

● Oxime Derivatives
- *O*-Aminocarbonyloximes
Synthesis
– *O*-methylaminocarbonyl-aldoximes from aldoximes and methyl isocyanate 321 (2861)
- *O*-Sulfonyloximes
Synthesis
– *O*-mesitylsulfonyl-ketoximes from ketones and *O*-mesitylsulfonylhydroxylamine 215
Reactions
– *o*-benzoquinone mono[*O*-phenylsulfonyloximes] + aqueous pyridine 346
– benzyl phenyl ketone *O*-mesityl sulfonyloxime + sodium ethoxide 215
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● Oxime Nitronates
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● Oximes
- General
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- Regeneration of the Carbonyl Compound
– – with aluminum triiso-propoxide 433 (2952)
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- without Cyclization
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Synthesis
– *N*-acetyl-7-oximino-10-decanelactam 313
– *N*-acetyl-6-oximino-9-nonanelactam 313
– *N*-acetyl-12-oximino-15-penta-decanelactam 313
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– *anti*-α-amino-ketoximes + carbonyl chloride + triethyl-amine 183 (2757)
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– – with cerium(IV) ammonium nitrate 349

● Oxirene

- Oxiranes
Synthesis
- of the Ring Skeleton
– – from aldehydes, *gem*-dibromo-alkanes, and lithium or butyl-lithium 182 (2751)
– – from electron-deficient ole-fins and cumyl hydroperoxide/base 64 (2642)
– – from *vic*-halohydroxyalkanes via *O*-stannylation and thermo-lysis 64 (2641)
– – from *vic*-halostannyloxyalkanes by thermolysis 64 (2641)
– – from ketones, *gem*-dibromo-alkanes, and lithium or butyllithium 182 (2751)
– 3-chloro-2,2-dialkyloxiranes from dialkyl ketones and dichloromethyllithium 403
– ethoxycarbonyloxiranes from ethyl α-lithiocarboxylates and aldehydes or ketones 234 (2807)
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- Ring-Cleavage Reactions
– – with alkyl halides + quaternary aminium salts 451
– – with 1-lithioalkyl iso-cyanides 699 (3215)
– – with sodium amide and 2-unsubstituted *N,N*-dialkyl-alkanamides 179 (2736)
– – with sulfurated sodium borohydride 176 (2723)
– ethynyloxiranes + trialkyl-boranes + oxygen 305
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– methyloxirane + 2-acetoxy-1-methyl-3-oxocyclopentene + tin(IV) chloride 404

● Oxonium Salts
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● Penams
see: Penicillins and Relatives; 4-Thia-1-azabicyclo[3.2.0]-heptanes, 7-oxo

● Penicillins and Relatives

Penam

Synthesis
– 3-aminocarbonyl-2,2,6-trimethyl-penams from 2-(1-carboxyethyl)-5,5-dimethyl-2,5-dihydro-1,3-thia-zole and isocyanides 345
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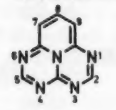
– 1-oxo-6β-phenylacetylamino-penicillanic acid, ring enlarge-ment to a 3-cephem 702 (3228)

● **1,3,4,6,9b-Pentaazaphenalene**



Synthesis
- of the Ring Skeleton
– – from 2,6-diaminopyridine and alkyl *N*-cyanoalkanimidates 376 (2930)

● **Pentalene**

Synthesis
- of the Ring Skeleton
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– glycyl peptides from amino-acids or peptides and *N*-carboxy-glycine anhydride 241 (2837)
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- Synthesis
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see also: Carboperoxoic Acids, Carboperoxoic Acid Esters, Diacyl Peroxides, Hydroperoxy Compounds, Peroxylactones, etc.
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– 1,10-dithia[2.2]orthometa-cyclophane 101
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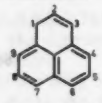
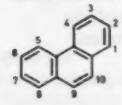
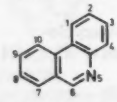


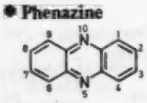
- 2,3,3a,4,5,6-Hexahydrophenalenes
Synthesis
- from Like Ring Skeletons
– 8-methoxy-3a-methyl der. from corresponding 1-oxo der. 308
- of the Ring Skeleton
– 8-methoxy-3a-methyl-1-oxo der. 308
Reactions
- Retention of the Ring Skeleton
– 8-methoxy-3a-methyl der. + chromium(IV) oxide/acetic acid 308
– 8-methoxy-3a-methyl-1-oxo der. + potassium hydroxide + hydrazine 308
- 2,3,3a,4,5,6,8,9b-Octahydrophenalenes
Synthesis
- from Like Ring Skeletons
– 9b-hydroxy-3a-methyl-8-oxo der. 308
● Phenanthrene



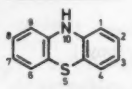
Reactions
- Retention of the Ring Skeleton
– – with cerium(IV) ammonium nitrate 352
● Phenanthridine



- 5,6-Dihydrophenanthridines
Synthesis
- of the Ring Skeleton
– 6,6-dimethyl der. from 2-isopropylidenaminobiphenyls by irradiation 821 (3327)
– 6-oxo der. from 2-biphenylyl isocyanates by irradiation 821 (3327)
– 6-oxo der. from 6-oxo-6*H*-dibenzo[*b*,*d*]pyrans and ammonia or primary amines 565 (3097)
- 5,6,7,8,9,10-Hexahydrophenanthridines
Synthesis
- of the Ring Skeleton
– 6-oxo der. from 6-oxo-7,8,9,10-tetrahydro-6*H*-dibenzo[*b*,*d*]pyrans and ammonia or primary amines 565 (3097)
● Phenazine



Synthesis
- from Like Ring Skeletons
– 5,10-bis-oxide 68 (2658)
- of the Ring Skeleton
– 5,10-dioxides from benzofurazan 1-oxide and phenols 186 (2767)
● Phenols
- General
Synthesis
– *o*-(2-nitroalkyl)-phenols from *o*-phenolic Mannich bases and nitroalkanes 754
– phenol acetates from arenes and lead(IV) acetate 574
Reactions
- involving the Phenolic Group
– – with lithium alanate 796
-not involving the Phenolic Group
– – aminomethylation by Mannich reaction 720
– – with 3-alkyl-3,4-dihydro-2*H*-1,3-benzoxazine 721
- Diphenols
Synthesis
– 5-alkyl-1,3-dihydroxybenzenes from ethyl acetoacetate and alkyl 2-alkenoates (2 steps) 627 (3116)
Reactions
– catechol + dialkyl acetylenedicarboxylates + base 374 (2922)
- Naphthols
Reactions
– 1-naphthol + Mannich bases 753
- Phenol and Substitution Products
Synthesis
– alkylbis[2-hydroxybenzyl]-amines from phenols and 3-alkyl-3,4-dihydro-2*H*-1,3-benzoxazines 721
– dialkylaminophenols from phenols and *N*-chlorodialkylamines 5
– 3,4,5-trimethoxyphenol 432 (2946)
Reactions
- involving the Phenolic Group
– 2-aminomethylphenols + trialkyl phosphites 759
– 2-aminophenol + *N*-dichloromethylenesulfonamides 323 (2870)
– 2,6-disubstituted phenols + periodic acid 357
● Phenothiazine



Synthesis
- from Like Ring Skeletons
– *N*-alkylphenothiazines from phenothiazine, alkyl halides, and thallium(I) ethoxide 551 (3041)
● Phosphine Dihalides
Synthesis
– triphenylphosphine difluoride 787
● Phosphine Imides
Synthesis
– triphenylphosphine imide 472
– triphenylphosphine *N*-phenylimide 472
Reactions
– – with nitrile imines 482
– triphenylphosphine *N*-phenylimide + benzonitrile oxide 482
– triphenylphosphine *N*-phenylimide + diphenylcarbodiimide 482
● Phosphine Oxides
Synthesis
– – from phosphine sulfides and dimethyl sulfoxide 307
– – from tertiary phosphines and cerium(IV) ammonium nitrate 354
– 2-chloroethyl-diphenylphosphine oxide 234 (2805)
– 1-dibutylphosphinyl-2-diphenylphosphinylethane 234 (2905)
– diphenyl-2-hydroxyethylphosphine oxide 234 (2805)
Reactions
– aryldialkylphosphine oxides + boron trisulfide 692 (3189)
● Phosphines
- General
Reactions
– tertiary phosphines + 1-alkoxymethyl-2-oxohexahydropyrimidines + acid 280
– tertiary phosphines + cerium(IV) ammonium nitrate 354
– tertiary phosphines + 1-hydroxymethyl-2-oxohexahydropyrimidines + acid 280
- Acylphosphines
Synthesis
– acyldiphenylphosphines from acyl chlorides and diphenyl-(trimethylsilyl)-phosphine 693 (3190)
- 1-Alkenylphosphines
Synthesis
– dialkyl bis[diphenylphosphino]-maleates from dialkyl dichloromaleates and diphenyl-(trimethylsilyl)-phosphine 693 (3190)
– diphenylphosphinocyclobutenediones from chlorocyclobutenediones and diphenyl-(trimethylsilyl)-phosphine 693 (3190)
- Alkylarylphosphines Type RArPH
Reactions
– 1-carboxyalkyl-phenylphosphines + aldehydes or ketones 183 (2755)
– 2-hydroxyalkylarylphosphines + aldehydes or ketones + tosic acid 120 (2703)
- Dialkylphosphines Type R_2PH
Reactions
– alkyl 2-hydroxyalkylphosphines + ketones + tosic acid 120 (2703)
- Triarylphosphines
Reactions
– triphenylphosphine + (1.) bromine, (2.) aniline/triethylamine 472
● Phosphine Sulfides
Synthesis
– optically active aryldialkylphosphine sulfides from optically active aryldialkylphosphine oxides and boron trisulfide 692 (3189)
Reactions
– – with dimethyl sulfoxide + acid 307
● Phosphinic Acid Esters
Synthesis
– methyl 2,2'-disubstituted diethylphosphinates from acrylic acid derivatives and methyl hypophosphite 501 (3003)
● Phosphinic Acid Halides
Synthesis
– dibenzylphosphinic fluoride 787
● Phosphinous Acids
Reactions
– dibutylphosphinous acid + (1.) lithium, (2.) 2-chloroethyldiphenylphosphine oxide 234 (2805)
● Phosphonic Acid Dihalides
Synthesis
– 2-oxohexahydro-1-pyrimidylmethanephosphonyl dihalides from 1-hydroxymethyl (alkoxymethyl)-2-oxohexahydropyrimidines and phosphorus(III) halides 280
– phosphonic dichlorides from thiophosphonic dichlorides and thionyl chloride 436 (2967)
Reactions

– chloromethanephosphonic dichloride + ureas 288

● Phosphonic Acid Esters

- Alkanephosphonic Acid Esters

Synthesis

– dialkyl 3-acetoxy-2-acetoxymethylpropanephosphonates from dimethyl phosphite and 1,3-diacetoxy-2-methylenepropane 558 (3068)

– dialkyl alkanephosphonates from Mannich bases and trialkyl phosphites 759

– dialkyl alkylthiomethanephosphonates from trialkyl phosphite and alkyl chloromethyl sulfides 669

– dialkyl arylthiomethanephosphonates from trialkyl phosphite and aryl chloromethyl sulfides 669

– dialkyl 1,1-dialkoxyethanephosphonates from trialkyl phosphites, trialkyl orthoacetates, and phosphorus(III) chloride 547

– dialkyl 1-hydroxyalkanephosphonates from ketones, dialkyl phosphites, and base 64 (2639)

– dialkyl 2-oxohexahydro-1-pyrimidylmethanephosphonates from 1-halomethyl-2-oxohexahydropyrimidines and trialkyl phosphites 280

– dialkyl 4-oxotetrahydro-1,3,5-oxadiazin-3-ylmethanephosphonates from 3-halomethyl-4-oxotetrahydro-1,3,5-oxadiazines and trialkyl phosphites 248

– diethyl 1-alkylalkanephosphonates from diethyl 1-alkyl-1-alkenephosphonates and hydrogen/Raney nickel 364

– diethyl 2-oxo-2-phenylethanephosphonates from ω-bromoacetophenones and triethyl phosphite 688 (3170)

Reactions

– diethyl 1-alkyl-1-hydroxyalkanephosphonates + thionyl chloride/pyridine 354

- 1-Alkenephosphonic Acid Esters

Synthesis

– dialkyl 1-alkoxyethylenephosphonates from dialkyl 1,1-dialkoxyethanephosphonates, thermally 547

– dialkyl-1-alkoxyethylenephosphonates from trialkyl phosphites, trialkyl orthoacetates, and phosphorus(III) chloride 547

– diethyl 1-alkyl-1-alkenephosphonates from diethyl 1-alkyl-1-hydroxyalkanephosphonates and thionyl chloride/pyridine 364

– dialkyl 2-amino-1-alkenephosphonates from dialkyl 1-alkynephosphonates and amines 813 (3296)

- 2-Alkenphosphonic Acid Esters

Synthesis

– diethyl 2-chloromethyl-2-propenephosphonate 632 (3139)

- 1-Alkynephosphonic Acid Esters

Reactions

– – with primary or secondary amines 813 (3296)

- Diphosphonic Acid Esters

Synthesis

– tetraalkyl 4-oxotetrahydro-1,3,5-oxadiazine-3,5-bis[methanephosphonates] 248

– tetraethyl 2-methylenepropane-1,3-diphosphonate 632 (3139)

- Heterocyclic Phosphonic Acid Esters

Synthesis

– dialkyl 2-oxohexahydropyrimidine-4-phosphonates from 4-chloro-2-oxohexahydropyrimidines and dialkyl phosphites 270

– dialkyl 2-oxohexahydropyrimidine-4-phosphonates from 4-hydroxy-2-oxohexahydropyrimidines and dialkyl phosphites 269

- Miscellaneous Types

Synthesis

– 1,2-*O*-(1-dialkylphosphonoethylidene)-furanoses 700 (3219)

– 1,2-*O*-(1-dialkylphosphonoethylidene)-pyranoses 700 (3219)

● Phosphonic Acids

- Alkanephosphonic Acids

Synthesis

– aminomethanephosphonic acids from phosphorous acid, formaldehyde, and ammonia or amines 743

– nitrilo-tris[methylenephosphonic acid] 436 (2966)

– ureidomethanephosphonic acids from 4-halo-2-oxotetrahydro-1,3,4-diazaphosphole 4-oxides 288

● Phosphonium Betaines

Synthesis

– (triphenylphosphoniomethyl)-boranate betaines from methylenetriphenylphosphorane and boranes 649

● Phosphonium Salts

- Acyloxyphosphonium Salts

Synthesis

– – from carboxylic acids, triphenylphosphine, and carbon tetrachloride 60 (2623)

- 1-Alkenylphosphonium Salts

Reactions

– 3-oxo-1-alkenylphosphonium bromides + primary diazoalkanes 236 (2815)

- 2-Alkenylphosphonium Salts

Reactions

– allyltriphenylphosphonium chloride + butyllithium + ethyl 2-acetyl-3-methyl-2-butenoate 60 (2626)

- Alkyltriarylphosphonium Salts

Synthesis

– – from triphenylphosphine and Mannich base methiodides 759

– *N,N'*-bis[triphenylphosphoniomethyl]-*N,N'*-dialkylurea chlorides from 3,5-dialkyl-4-oxotetrahydro-1,3,5-oxadiazines, triphenylphosphine, and hydrogen chloride 248

– 3-chloro-3-triphenylphosphoniophthalide chloride 322 (2869)

– *P*-(methoxymethylaminocarbonylaminomethyl)-triphenylphosphonium chlorides from 4-oxotetrahydro-1,3,5-oxadiazines, triphenylphosphine, methanol, and hydrogen chloride 248

– 2-oxo-1-triarylphosphoniomethylhexahydropyrimidine halides from 1-hydroxymethyl-(alkoxymethyl)-2-oxohexahydropyrimidines, triarylphosphines, and hydrogen halide 280

Reactions

– methyltriphenylphosphonium bromide + sodium triethylboranate 649

- Bis[phosphonium]Salts

Synthesis

– 3,5-bis[triphenylphosphoniomethyl]-4-oxotetrahydro-1,3,5-oxadiazine dibromide 248

– cyanomethylene-bis[triphenylphosphonium] dibromide 180 (2738)

- Tetraalkylphosphonium Salts

Synthesis

– 2-oxo-1-trialkylphosphoniomethylhexahydropyrimidine halides from 1-hydroxymethyl-(alkoxymethyl)-2-oxohexahydropyrimidines, trialkylphosphines, and hydrogen halide 280

● Phosphonoamidic Acid Esters

Synthesis

– alkyl *N*-aminocarbonylchloromethanephosphonoamidates from *N*-aminocarbonylchloromethanephosphonoamidic chloride and alcohols 288

● Phosphonoamidic Acid Halides

Synthesis

– *N*-aminocarbonylchloromethanephosphonic chlorides from chloromethanephosphoric dichloride and ureas 288

● Phosphonothioic Acid Esters

- Alkanephosphonothioic Acid Esters

Synthesis

– *O,O*-diethyl 2-oxoalkanephosphonothioates from *O,O*-diethyl 1-alkynephosphonothioates and alkylamines 372 (2911)

- 1-Alkynephosphonothioic Acid Esters

Reactions

– *O,O*-diethyl 1-alkynephosphonothioates + butylamine 372 (2911)

● Phosphoranes

for Reactions of Alkylidenephosphoranes and derivatives, *refer also to* Reaction Index, Carbonyl Olefination

- Alkylidenephosphoranes

Synthesis

– 1-alkoxycarbonyl-2-aryl-3-nitropropylidenephosphoranes from alkoxycarbonylmethylenetriphenylphosphoranes and 1-nitro-1-alkenes 813 (3295)

– alkylidenediphenyl-(polystyryl)-phosphoranes 56 (2607)

– chlorofluoromethylenetriphenylphosphorane *in situ* 113 (2670)

– cyanomethylenetriphenylphosphorane 180 (2738)

– 1-heteroarylalkylidenetriphenylphosphoranes from alkylidenetriphenylphosphoranes and *C*-chloro-*N*-heteroarenes 187 (2773)

Reactions

– alkylidenetriphenylphosphoranes + *C*-chloro-*N*-heteroarenes 187 (2773)

- Heterocyclic Phosphoranes

Synthesis

– 4-acyl-3-triphenylphosphoranylidene-3*H*-pyrazoles from 3-oxo-1-alkenyltriphenylphosphonium bromides and primary diazoalkanes 236 (2815)

– 2,4-dioxo-3-triphenylphosphoranylidene-1,2,3,4-tetrahydroquinolines from 2,4-dioxo-1,2-dihydro-4*H*-3,1-benzoxazines and alkoxycarbonylmethylenetriphenylphosphoranes 813 (3295)

- 2-Oxoalkylidenephosphoranes

Synthesis

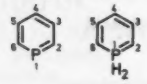
– 2-oxoalkylidenetriphenylphosphoranes from 2-oxopropylidenephosphoranes by lithiation and alkylation '59 (2619)

Reactions

– – with 3-dialkyl amino-methylindoles 753
– 2-oxoalkylidenetriphenyl-phosphoranes + 1-azido-alkenes 817 (3311)

● Phosphoric Acid Esters
Synthesis
– diphenyl 3-oxo-3-phenyl-propenyl phosphates from diphenylphosphorochlori-date and sodium 3-oxo-3-phenylpropneoxides 806 (3264)
– trialkyl phosphates from dialkyl phosphites, ketones, and base 64 (2639)
Reactions
– diphenyl 3-oxo-3-phenyl-propenyl phosphates + pyridine 813 (3294)
– diphenyl 3-oxo-3-phenyl-propenyl phosphates + sodium iodide 806 (3264)
– diphenyl 3-oxo-3-phenyl-propenyl phosphates + sodium sulfide 811 (3286)
– diphenyl 3-oxo-3-phenyl-propenyl phosphates + tri-methylamine 813 (3294)

● Phosphorin



P^V

- Phosphorins
Reactions
- Retention of the Ring Skeleton
– 2,4,6-triphenylphosphorin + benzenediazonium tetrafluoro-borates 437 (2969)
– 2,4,6-triphenylphosphorin + halogen 437 (2968)

- P^V-Phosphorins
Synthesis
- from Like Ring Skeletons
– 1-alkoxy-1,2,4,6-tetraphenyl P^V-phosphorins from 2,4,6-tri-phenylphosphorin, benzenedi-azonium tetrafluoroborates, and alcohols 437 (2969)
– 1,1-dihalo-2,4,6-triphenyl-P^V-phosphorins from 2,4,6-tri-phenylphosphorin and bromine or chlorine 437 (2968)
– 1-fluoro-1,2,4,6-tetraphenyl-P^V-phosphorins from 2,4,6-tri-phenylphosphorin and benzenedi-azonium tetrafluoroborates 437 (2969)

● Phosphoroamidic Acid Esters
Synthesis
– dialkyl *N*-(1-alkenyl)-phosphoro-amidates from dialkyl phosphoro-amidates and disubstituted acet-aldehydes 692 (3186)
– diaryl *N*-(1-alkenyl)-phosphoro-amidates from diaryl phosphoro-amidates and disubstituted acet-aldehydes 692 (3188)

● Phosphoroamidothioic Acid Esters
- *O,O*-Esters
Synthesis
– *O,O*-diaryl *N*-(1-alkenyl)-phosphoroamidothioates from *O,O*-diaryl phosphoro-amidothioates and disubsti-tuted acetaldehydes 692 (3188)

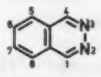
● Phophoroimidic Acid Esters
Synthesis
– triphenyl *N*-(1-bromo-3-cyano-1-alkenyl)-phosphoroimidates from 1-bromo-1,2-dicyanoalkanes and triphenyl phosphite 813 (3297)

● Phosphorothioic Acid Esters
Synthesis
– *O,O*-diethyl *S*-diphenyl-methyl phosphorothioate 64 (2639)

● Phosphorous Acid Esters
- Dialkyl Phosphites
Reactions
– – with 4-hydroxy-2-oxo-hexahydropyrimidines 269

- Trialkyl Phosphites
Reactions
– – with 1-halomethyl-2-oxo-hexahydropyrimidines 280

● Phthalazine



- 1,2-Dihydrophthalazines
Synthesis
- from Like Ring Skeletons
– – from phthalazines and dodecacarbonyltriiron/methanol 498 (2988)

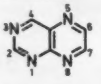
● Polyenes (conjugated)
Synthesis
– 1-oxo-1,3,5,7-tetraphenyl-2,4,6-octatriene 674
Reactions
– 1,2-bis[methylene]-cyclo-hexadienes + dienophiles 416

● Polyynes
Synthesis
– – from 1,ω-bis[trialkylsilyl]-polyynes by alkaline hydro-lysis 805 (3259)
– 1,ω-bis[trialkylsilyl]-polyynes from ethynyltrialkylsilanes or trialkylsilylbutadiyne, copper(I)-tertiary amine complexes, and oxygen 805 (3259)

● Prostaglandin Precursors
Synthesis
– ethyl 2-(3-hydroxy-1-octynyl)-5-oxocyclopentene-1-heptanoate 404
– 4-formyl-5-hydroxy-2-oxohexa-hydrocyclopenta[*b*]furan 354
– 3-hydroxy-5-oxo-2-styrylcyclo-pentene-1-heptanoic acid 399
– methyl 5-hydroxy-3-oxocyclo-pentene-1-heptanoate 411
– 2-(7-octenyl)-3-oxocyclopentene 410

● Prostaglandins and Relatives
Synthesis
– 4-(2-alkenyl)-3-(2-butenyl)-5-oxocyclopentenes 412
– ethyl 2-oxocyclopentane-heptanoate 751
– prostaglandin B_1 404

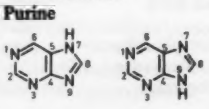
● Pteridine



- Pteridines
Synthesis
- of the Ring Skeleton
– α-fluorofolic acid 44

- 3,4-Dihydropteridines
Synthesis
- of the Ring Skeleton
– 4-oxo der. from 4-oxo-4*H*-pyrazino[2,3-*d*][1,3]oxazines and ammonia 506 (3020)

● Purine



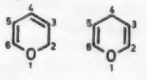
9*H*–

- Purines
Reactions
- Fusion of New Rings
– 2-azidopurines, azido-tetrazolo-isomerization 129

- 9*H*-Purines
Reactions
- Retention of the Ring Skeleton
– 6-thio der., *N*-aminomethylation by Mannich reaction 740

- 1,2,3,6-Tetrahydropurines
for 2,6-dioxo derivatives, *refer also to* Xanthines
Synthesis
- of the Ring Skeleton
– 8-amino-1,3-dimethyl-2,6-dioxo der. from 6-amino-1,3-dimethyl-5-nitrosouracils and formamides 67 (2655)
– 7-aryl-1,3-dimethyl-2,4-dioxo der. from alkylamino 1,3-dimethyl-uracils and nitrosobenzenes 817 (3313)
– 1,3-dimethyl-2,6-dimethyl-2,6-dioxo-8-(indolyl)-der. from 6-amino-1,3-dimethyl-5-nitroso-uracil and *N*-(indolylmethyl)-aminium salts 772
– 1,3-dimethyl-1,6-dioxo-8-phenyl der. from 6-amino-1,3-di-methyl-5-nitrosouracil and hydroxybenzylaminium salts 772

● Pyran



2*H*– 4*H*–

see also: Pyrones

- Pyrylium Salts
Reactions
- Retention of the Ring Skeleton
– methylpyrylium salts, α-(amino-methylation) by Mannich reaction 734
- Transformation of the Ring Skeleton
– – with cyanamide + base 66 (2652)

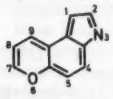
- 3,4-Dihydro-2*H*-pyrans
Synthesis
- of the Ring Skeleton
– – from 2-aminoalkyl ketones and 1-alkenes 769
– 2-acyl der. from 2-amino-alkyl ketones by deamination 745
– 3-chloro-2,2-dimethoxy der. from 2-alkenals and chloro-ketene dimethyl acetal 236 (2817)
– 3-chloro-2,2-dimethoxy der. from 1-alkenyl ketones and chloroketene dimethyl acetal 236 (2817)
– 2,2-dialkyl-6-phenyl der. from 1-methylphenylamino-1-phenylpropene, butyllithium, and 2,2-dialkyloxiranes 418
– 4-oxo der. from 2-(2,2-dimethoxy-ethyl)-2-lithio-1,3-dithiane and oxiranes (multistage synthesis) 696 (3205)
Reactions
- Ring-Cleavage Reactions
– – ozonolysis 66 (2647)

- 5,6-Dihydro-2*H*-pyrans
Reactions
- Fusion of New Rings
– 3-formyl der. + ureas + acid 291

- Tetrahydropyrans
Synthesis
- of the Ring Skeleton
– – from 1,5-dihydroxypentane and Amberlyst 15 209
– 3,6-diethenyl der. from aldehydes and butadiene 67 (2653)

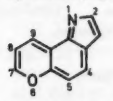
Reactions
- Retention of the Ring Skeleton
– 3-oxo der., aminomethylation by Mannich reaction 730

● **Pyrano[3,2-*e*]indole**



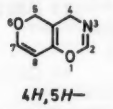
- 3,7,8,9-Tetrahydropyrano[3,2-*e*]indoles
Synthesis
- of the Ring Skeletons
– 7-oxo der. from 4-dialkylamino-5-hydroxyindoles and alkanoic acid esters 771

● **Pyrano[2,3-*g*]indole**



- 1,7,8,9-Tetrahydropyrano[2,3-*g*]-indoles
Synthesis
- of the Ring Skeleton
– 7-oxo der. from 7-dialkylamino-6-hydroxyindoles and alkanoic acid esters 771

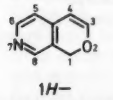
● **Pyrano[3,4-*e*]-1,3-oxazine**



4H,5H–

Synthesis
- of the Ring Skeleton
– 7-chloro-4,5-dioxo der. from malonyl chloride and nitriles 192

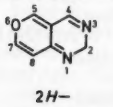
● **Pyrano[3,4-*c*]pyridine**



1H–

- 3,4,4a,5,6,7-Hexahydro-1*H*-pyrano[3,4-*c*]pyridines
Synthesis
- of the Ring Skeleton
– 1-oxo der. from 3-methoxycarbonyl-1-azoniabicyclo[2.2.2]-oct-2-ene halides, thermally 506 (3022)

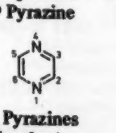
● **Pyrano[4,3-*d*]pyrimidine**



2H–

- Octahydropyrano[4,3-*d*]pyrimidines
Synthesis
- from Like Ring Skeletons
– 4-hydroxyphenyl-2-oxo der. from 2-oxo der. and phenols 268
- of the Ring Skeleton
– 2-oxo-4-ureido der. from 3-formyl-5,6-dihydro-2*H*-pyrans and ureas 291
Reactions
- Retention of the Ring Skeleton
– 4-hydroxy-2-oxo der. + phenols + acid 268

● **Pyrazine**

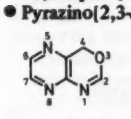


- Pyrazines
Synthesis
- from Like Ring Skeletons
– 2-(1,4-dioxanyl)-pyrazine 16
- of the Ring Skeleton
– 2,3-dihydroxypyrazines from α-amino ketone acetals and ethyl oxamate 185 (2766)
Reactions
- Fusion of New Rings
– – with diphenylcyclopropenone 120 (2704)
– 2-aminopyrazine-3-carboxylic acid + carboxylic anhydrides 506 (3020)

- 1,2-Dihydropyrazines
Reactions
- Transformation of the Ring Skeleton
– 2-oxotetraalkyl der., irradiation 439 (2976)

- 2,3-Dihydropyrazines
Reactions
- Fusion of New Rings
– 5,6-diphenyl der. + ketenes 332

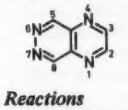
● **Pyrazino[2,3-*d*][1,3]oxazine**



4H–

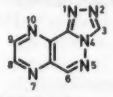
Synthesis
- of the Ring Skeleton
– 4-oxo der. from 2-aminopyrazine-3-carboxylic acid and carboxylic anhydrides 506 (3020)
Reactions
- Transformation of the Ring Skeleton
– 4-oxo der. + ammonia 506 (3020)

● **Pyrazino[2,3-*d*]pyridazine**



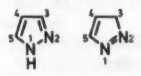
Reactions
- Fusion of New Rings
– 5,8-dichloro der. + sodium azide 84

● **Pyrazino[2,3-*d*]tetrazolo[4,5-*b*]-pyridazine**



Synthesis
- of the Ring Skeleton
– 6-azido der. 84

● **Pyrazole**



3H–

- Pyrazoles
Synthesis
- from Like Ring Skeletons
– 3(5)-aminopyrazole 294
– 1-nitropyrazole 294
– 3(5)-nitropyrazole 294
- of the Ring Skeleton
– – from sydnones and alkenes 479
– – from sydnones and alkynes 476
– 4-acylpyrazoles from 3-oxo-1-alkenylphosphonium bromides and primary diazoalkanes 236 (2815)
– 3-aryl-5-ethynylpyrazoles from aryl silylbutadiynyl ketones and hydrazine 47
Reactions
- Retention of the Ring Skeleton
– 3(5)-nitropyrazole + hydrogen/palladium 294
– 1-nitropyrazole, thermal isomerization 294
– pyrazole + nitric acid/acetic acid/acetic anhydride 294

- 3*H*-Pyrazoles
Synthesis
- of the Ring Skeleton
– 4-acyl-3-triphenylphosphoranylidene-3*H*-pyrazoles from 3-oxo-1-alkenyl-phosphonium bromides and primary diazoalkanes 236 (2815)

- 2,3-Dihydropyrazoles
Synthesis
- from Like Ring Skeletons
– 2-acyl-3-amino-5-oxo-1-phenyl der. from 3-azidocarbonyl-5-oxo-6-phenyl-4,5-dihydropyrazoles and carboxylic acids 633 (3142)
- of the Ring Skeleton
– 3-oxo-5-phenyl der. 679

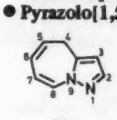
- 2,5-Dihydropyrazoles
Synthesis
- of the Ring Skeleton
– 3-phenyl der. from 2-hydrazinoethyl phenyl ketones *in situ* 769
Reactions
- Retention of the Ring Skeleton
– 2,3-dimethyl-5-oxo-1-phenyl der., aminomethylation by Mannich reaction 727

- 4,5-Dihydropyrazoles
Synthesis
- from Like Ring Skeletons
– 1-aminocarbonyl-3,5-diaryl der. from 3,5-diaryl der. and isocyanates 324 (2872)
– 1-aminothiocarbonyl-3,5-diaryl der. from 3,5-diaryl der. and isothiocyanates 324 (2872)
- of the Ring Skeleton
– – from sydnones and alkynes 479
– 1-phenyl der. from 2-aminoethyl styryl ketones and phenylhydrazine 766
Reactions
- Retention of the Ring Skeleton
– 3,5-diaryl der. + isocyanates 324 (2872)
– 3,5-diaryl der. + isothiocyanates 324 (2872)
– 5-oxo der., aminomethylation by Mannich reaction 727
- Ring-Cleavage Reactions
– 3-alkyl-5-oxo der. + thallium(III) nitrate + methanol 630 (3130)
- Transformation of the Ring Skeleton
– 5-hydroxy-4-(2-oxoalkylidene)-1-phenyl der., thermolysis 819 (3320)

- 4,5-Dihydro-3*H*-pyrazoles
Synthesis
- of the Ring Skeleton
– 3-phenyl der. from styrenes and diazomethane 78

- Pyrazolidines
Synthesis
– 1-cyanopyrazolidine(3-spiro-9)-fluorenes from *N*-(cyanoimino)-fluorene-9-iminium ylids and alkenes 476
- of the Ring Skeleton
Reactions
- Transformation of the Ring Skeleton
– 5-oxo-1-phenyl der. irradiation 344

● **Pyrazolo[1,5-*a*]azepine**

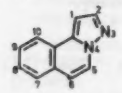


4H–

- 5,6,7,8-Tetrahydro-4*H*-pyrazolo-[1,5-*a*]azepines
Synthesis
- of the Ring Skeleton

– 2,3-dimethoxycarbonyl-8-oxo der. 503 (3009)

● **Pyrazolo[3,2-*a*]isoquinoline**



- 1,10b-Dihydropyrazolo[3,2-*a*]-isoquinolines

Synthesis

- of the Ring Skeleton

– 2-methyl der. 476

- 1,2,3,5,6,10b Hexahydropyrazolo-[3,2-*a*]isoquinolines

Synthesis

- of the Ring Skeleton

– 3-aryl der. from 2-arylimino-3,4-dihydroisoquinolinium ylids and alkenes 478

● **Pyrazolo[1,5-*a*]pyridine**

- Pyrazolo[1,5-*a*]pyridines

Synthesis

- of the Ring Skeleton

– 2,3-dialkoxycarbonyl der. from 1-aminopyridinium iodides and dialkyl chlorofumarates (3 steps) 634 (3147)

– 2,3-dimethoxycarbonyl der. from 1-(ethoxycarbonylimino)-pyridinium ylids and dimethyl acetylenedicarboxylate 477

- 3,3a-Dihydropyrazolo[1,5-*a*]-pyridines

Synthesis

- of the Ring Skeleton

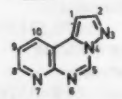
– 2,3-dialkoxycarbonyl der. from 1-aminopyridinium iodides and dialkyl chlorofumarates 634 (3147)

Synthesis

- of the Ring Skeleton

– 7-oxo der. from 2-diazo-cyclopentanone and alkynes 503 (3009)

● **Pyrazolo[2,3-*c*]pyrido[3,2-*e*]pyrimi-dine**

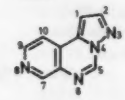


Synthesis

- of the Ring Skeleton

– – from 2-amino-3-(pyrazol-3-yl)-pyridines and triethyl ortho-carboxylates 68 (2660)

● **Pyrazolo[2,3-*c*]pyrido[4,3-*e*]pyrimi-dine**

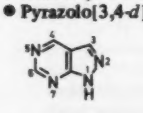


Synthesis

- of the Ring Skeleton

– – from 3-amino-4-(pyrazol-3-yl)-pyridines and triethyl ortho-carboxylates 68 (2660)

● **Pyrazolo[3,4-*d*]pyrimidine**



1*H*–

- 4,5,6,7-Tetrahydro-1*H*-pyrazolo-[3,4-*d*]pyrimidines

Synthesis

- of the Ring Skeleton

– 4,6-dioxo-3-phenyl der. from 6-benzylidenehydrazino-2,4-dioxo-1,2,3,4-tetrahydropyrimi-dines, thermally 300

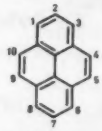
- 3a,4,5,6,7,7a-Hexahydro-1*H*-pyrazolo-[3,4-*d*]pyrimidines

Synthesis

- of the Ring Skeleton

– 6-oxo-1-phenyl der. from 5-acetyl-2-oxo-1,2,3,4-tetrahydro-pyrimidines and phenylhydrazines 290

● **Pyrene**



- 4,5-Dihydropyrenes

Synthesis

- of the Ring Skeleton

– – from 3,3'-bis[bromomethyl]-stilbene and sodium 88

- 10b,10c-Dihydropyrenes

Synthesis

- of the Ring Skeleton

– 10b, 10c-dimethyldihydropyrene 98

● **Pyrethrin Precursors**

Synthesis

– allethrolone 403, 405

– 3-hydroxy-2-methyl-5-oxo-1-pentylcyclopentene 403

– pyrethrolone 399

● **Pyridazine**

- Pyridazines

Synthesis

- from Like Carbon Skeletons

– pyridazine *N*-oxides from pyridazines and dichloromaleic anhydride/hydrogen peroxide 495

Reactions

- Fusion of New Rings

– – with diphenylcyclopropenone 120 (2704)

- Retention of the Ring Skeleton

– hydroxypyridazine 1-oxides, amino-methylation by Mannich reaction 729

- 2,3-Dihydropyridazines

Reactions

- Retention of the Ring Skeleton

– 3-oxo der., *N*-aminomethylation by Mannich reaction 740

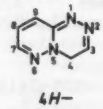
- 2,3,4,5-Tetrahydropyridazines

Synthesis

- of the Ring Skeleton

– 4-acyl-3-oxo-2-phenyl der. from 5-hydroxy-4-(2-oxoalkylidene)-1-phenyl-4,5-dihydropyrazoles, thermally 819 (3320)

● **Pyridazino[3,2-*c*][1,2,4]triazine**



4*H*–

Synthesis

- of the Ring Skeleton

– 7-azido-3-methyl-4-oxo der. 133

Reactions

- Ring-Cleavage Reactions

– 7-azido-3-methyl-4-oxo der. + hydrochloric acid 133

● **Pyridine**

- Pyridines

Synthesis

- from Like Ring Skeletons

– – from 1-methylpyridinium iodides, thermally 698 (3211)

– – from pyridine *N*-oxide and *O,O*-diethyl dithio-phosphate 174 (2712)

– alkylpyridines from pyridines by radical alkylation 13

– 2-(1-alkynyl)-pyridines from 2-iodopyridines, 1-alkynes, and copper 68 (2659)

– 4-cyano-2-(1,4-dioxanyl)-pyridine 16

– 2-cyanopyridine-3-acetonitrile 46

– 4-cyanopyridine-3-acetonitrile 46

– 4-dimethylaminopyridine 301

– 3-heteroarylpyridines from 3-iodopyridine and heteroarenes, photochemically 66 (2649)

– hydroxymethylpyridines from pyridine, methanol, and ammonium peroxydisulfate 17

– pyridine *N*-oxides from pyridines and *t*-pentyl hydro-peroxide/molybdenum(V) chloride 68 (2658)

- of the Ring Skeleton

– – from cyclopentadiene-(triphenylphosphine)-cobalt, alkynes, and nitriles 819 (3322)

– 3-acyl-2-aminopyridines from pyrylium perchlorates and cyanamide 66 (2652)

– 6-chloro-3-cyano-2,4-diamino-pyridines from *N,N*-disubstituted cyanoacetamides and phosphoryl chloride 563 (3089)

– 6-chloro-2,4-diamino-3-phenyl-pyridines from *N,N*-dialkyl-2-cyanoalkanamides, *N,N*-dialkyl-phenylacetamides, and phosphoryl chloride 563 (3089)

Reactions

- Fusion of New Rings

– 2-aminopyridines + 2-acetyl-4-butanolide + polyphosphoric acid 565 (3098)

– anilinotetrachloropyridines, irradiation 372 (2915)

– 2-bromopyridine + ammonium azide 84

– dimethyl pyridine-2,3-dicarboxylate + methyl ketones + base 186 (2768)

– phenoxytetrachloropyridines, irradiation 372 (2915)

– phenylthiotetrachloropyridines, irradiation 372 (2915)

- Retention of the Ring Skeleton

– – radical alkylation 12

– hydroxypyridines, aminomethyl-ation by Mannich reaction 730

- Pyridine *N*-Oxides

Reactions

- Retention of the Ring Skeleton

– – with *O,O*-diethyl dithio-phosphate 174 (2712)

- Pyridinium Salts

Synthesis

- from Like Ring Skeletons

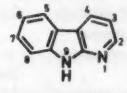
– 1-aminopyridinium mesitylene-sulfonates from pyridines and *O*-mesitylsulfonylhydroxyl-amine 549 (3036)

– 2-benzyl-1-phenacylpyridinium bromides from 2-benzylpyridines and ω-bromoacetophenones 238 (2825)

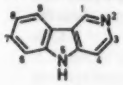
– 3-(2-nitriloethyl)-1-methoxypyri-dinium methylsulfate 46

– 1-(3-oxo-3-phenylpropenyl)-pyridinium diphenyl phosphates

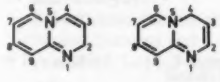
from diphenyl 3-oxo-3-phenylpropenyl phosphates and pyridine 813 (3294)
- *of the Ring Skeleton*
– 1-alkyl-2-chloro-3-cyano-4,6-diaminopyridinium chlorides from *N*-alkylcyanoacetamides and phosphoryl chloride 563 (3089)
Reactions
- *Retention of the Ring Skeleton*
– 4-alkoxy-1-methylpyridinium iodides, thermolysis 227 (2778)
– 1-aminopyridinium iodides + dialkyl chlorofumarates 634 (3147)
– 1-methylpyridinium iodides, thermolysis 698 (3211)
- **Pyridinium Ylids**
Synthesis
– 1-(1,2-dialkoxycarbonylethenylimino)-pydridinium ylids from 1-aminopyridinium iodides and dialkyl chlorofumarates 634 (3147)
– 1-ethoxycarbonyliminopyridinium ylid 470
– pyridinium cyclopentadienides from pyridines and diazocyclopentadienes 498 (2990)
– pyridinium phenacylide 469
Reactions
– 1-ethoxycarbonyliminopyridinium ylid + maleic anhydride 183 (2753)
– 1-ethoxycarbonyliminopyridinium ylid + maleimide 183 (2753)
– 1-iminopyridinium ylides + *O,O*-dialkyl dithiophosphates 174 (2712)
- **1,2-Dihydropyridines**
Synthesis
- *of the Ring Skeleton*
– 6-chloro-3-cyano-4-hydroxy-2-oxo der. 190
– 6-chloro-4-hydroxy-2-oxo der. from α-unsubstituted nitriles and malonyl chlorides 193
– 6-chloro-2-oxo der. from 4-chlorocarbonyl-2-alkenenitriles and hydrogen chloride 191
– 1-methyl-2-thiono der. from cyclopentadiene-(triphenylphosphine)-cobalt, alkynes, and methyl isothiocyanate 819 (3322)
Reactions
- *Transformation of the Ring Skeleton*
– 2-oxo der., irradiation 439 (2976)
- **1,4-Dihydropyridines**
Synthesis
- *from Like Ring Skeletons*
– 1-alkyl-3-aminocarbonyl-5-(3-indolylmethyl) der. from 1-alkyl-3-aminocarbonyl der. and 3-dimethylaminoindoles 634 (3149)
- *of the Ring Skeleton*
– 2,3-diphenyl-4-oxo der. from 1,2-oxazoles and diphenylcyclopropenone 820 (3323)
Reactions
- *Retention of the Ring Skeleton*
– 4-oxo der. + hexamethylphosphoric triamide 301
- **1,2,3,4-Tetrahydropyridines**
Synthesis
- *of the Ring Skeleton*
– 5-aryl-6-chloro-2-oxo der. from 4-aryl-4-cyanobutanoyl chlorides and hydrogen chloride 191
– 1,4-diphenyl-2-oxo der. from ketenes and *N*,3-diphenyl-2-propenimine 332
Reactions
- *Transformation of the Ring Skeleton*
– 5,6-(1,10-decanediyl) der. + butyl nitrite + acid 313
- **1,2,3,6-Tetrahydropyridines**
Synthesis
- *from Like Ring Skeletons*
– 1-benzyl der. from 1-benzylpyridinium halides and sodium borohydride 565 (3095)
– 1-unsubstituted der. from 1-benzyl der. and carbonyl chloride or phenyl carbonochloridate 565 (3095)
- **2,3,4,5-Tetrahydropyridines**
Synthesis
- *from Like Ring Skeletons*
– – from 1-acyl-2-oxopiperidines 440 (2981)
- **Piperidines**
Synthesis
- *from Like Ring Skeletons*
– 1,3-dialkylpiperidine-3-carboxylic acid der. from 1-alkyl-1,2,3,4-tetrahydropyridine-5-carboxylic acid der. and (1.) alkyl halides, (2.) hydrogen/palladium 565 (3096)
– *cis*-dialkylpiperidines from dialkylpyridines and hydrogen/ruthenium/carbon 220
– *all-cis*-2,4,6- trimethylpiperidine 220
- *of the Ring Skeleton*
– – from 5-alkylaminoalkanols 440 (2983)
– 2-aminocarbonyl-6-cyano der. from pentanedial, primary amines, and hydrogen cyanide 735
– 3-aroyl-4-aryl-4-hydroxy der. from bis[3-aryl-3-oxopropyl]-amines 767
– 3,5-dialkoxycarbonyl-4-oxo der. from dialkyl acetonedicarboxylates, aldehydes, and alkylamines 725
– 3,5-diaryl-4-oxo der. from 1,3-diarylacetones, formaldehyde, and primary amines 708
– 2,4-dioxo-6-phenyl-3,3,5,5-tetramethyl der. from 1,3-dioxotetramethylcyclobutane and benzaldimines 330
– tetrasubstituted 4-oxo der. from alkyl 2,4-diphenyl-3-oxobutanoates, formaldehyde, and alkylamines 725
Reactions
- *Fusion of New Rings*
– *N*-(2-oxoalkanoyl) der., irradiation 344
- *Retention of the Ring Skeleton*
– 1-alkyl-4-oxo der. aminomethylation by Mannich reaction 730
- *Ring-Cleavage Reactions*
– 2,6-diaryl-3,5-dialkoxycarbonyl-4-oxo der., base-catalyzed fragmentation 749
- **Piperidinium Salts**
Reactions
- *Retention of the Ring Skeleton*
– 2-unsubstituted 1,2-dimethyl-4-oxopiperidinium iodides + primary amines 755
- *Ring-Cleavage Reactions*
– 2-substituted 1,1-dimethyl-4-oxopiperidinium iodides + primary amines 755
● **Pyrido[2,3-*b*]indole**



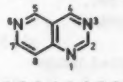
9*H*–
Synthesis
- *of the Ring Skeleton*
– 2,3,4-trichloro der. 372 (2915)
● **Pyrido[4,3-*b*]indole**



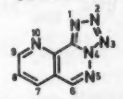
5*H*–
Synthesis
- *of the Ring Skeleton*
– 1,3,4-trichloro der. 372 (2915)
● **Pyrido[1,2-*a*]pyrimidine**



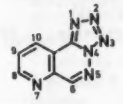
2*H*– 4*H*–
- **4*H*-Pyrido[1,2-*a*]pyrimidines**
Synthesis
- *of the Ring Skeleton*
– 2-methoxycarbonyl-4-oxo der. 134
- **3,4-Dihydro-2*H*-pyrido[1,2-*a*]-pyrimidines**
Synthesis
- *of the Ring Skeleton*
– 3-(2-hydroxyethyl)-2-methyl-4-oxo der. from 2-aminopyridines and 2-acetyl-4-butanolide 565 (3098)
● **Pyrido[4,3-*d*]pyrimidine**



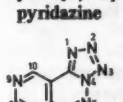
- **1,2,3,4,5,6,7,8-Octahydropyrido-[4,3-*d*]pyrimidines**
Synthesis
- *of the Ring Skeleton*
– 2-oxo-7-phenyl der. from 2-oxo-6-styryl-1,2,3,4-tetrahydropyrimidines, formaldehyde, and primary amines 283
– 7-phenyl- 2-thiono der. from 6-styryl-2-thiono-1,2,3,4-tetrahydropyrimidines, formaldehyde, and primary amines 283
● **Pyrido[2,3-*d*]tetrazolo[5,1-*b*]-pyridazine**



Synthesis
- *of the Ring Skeleton*
– – from 4-azidopyrido[2,3-*d*]-pyridazine by isomerization 130
● **Pyrido[3,2-*d*]tetrazolo[5,1-*b*]-pyridazine**

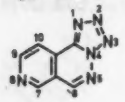


Synthesis
- *of the Ring Skeleton*
– – from 1-azidopyrido[2,3-*d*]-pyridazine by isomerization 130
● **Pyrido[3,4-*d*]tetrazolo[1,5-*b*]-pyridazine**



Synthesis
- *from Like Ring Skeletons*
– 6-azido der. 130

● **Pyrido[4,3-*d*]tetrazolo[1,5-*b*]-pyridazine**



Synthesis
- from Like Ring Skeletons
– 6-azido der. 130

● **Pyrimidine**

- Pyrimidines
Synthesis
- of the Ring Skeleton
– 2-anilino-6-hydroxy-4-methyl der. from N^1-aryl-biguanides and diketene 536
Reactions
- Fusion of New Rings
– 4,5-dihydroxy der. + formaldehyde + alkylamines 729
- Retention of the Ring Skeleton
– 2,4-dihydroxy der., aminomethylation by Mannich reaction 730
– 4,6-dimethoxy-5-nitro der., thermolysis 324 (2874)
- Ring-Cleavage Reactions
– 4-amino-6-chloro-5-nitro der. + sodium azide + hydrochloric acid 132
– 4-hydrazino der., attempted nitrosation 131

- 1,2-Dihydropyrimidines
Synthesis
- of the Ring Skeleton
– 6-chloro-2-(4-nitrobenzyl)-4-oxo der. 201
– 4-chloro-2-oxo der. from 3-isocyanato-2-alkenenitriles and hydrogen chloride 634 (3148)
– 2-imino der. from 1,3-dicarbonyl compounds and guanidine 258
– 2-oxo der. from 1,3-dicarbonyl compounds and urea 258
– 2-oxo der. from β-oxo-aldehyde bis[dimethyl acetals]and urea 259
– 2-thiono der. from 1,3-dicarbonyl compounds and thiourea 258
– 2-thiono der. from β-oxo-aldehyde bis[dimethyl acetals] and thiourea 259

- 2,5-Dihydropyrimidines
Synthesis
- of the Ring Skeleton
– 5,5-disubstituted 2-alkylidene-4,6-dichloro der. from disubstituted acetonitriles, carbonyl chloride, and hydrogen chloride 195

- 3,4-Dihydropyrimidines
Synthesis
- of the Ring Skeleton
– 2-alkyl-6-chloro-4-oxo der. from alkanenitriles, carbonyl chloride, and hydrogen chloride 195
– 6-chloro-4-oxo der. from nitriles and malonyl chlorides 194

- 4,6-Dihydropyrimidinium Betaines
Synthesis
– 1,3-dimethyl-4,6-dioxo-5-nitro-4,6-dihydropyrimidinium betaines from 4,6-dimethoxy-5-nitropyrimidines, thermally 324 (2874)

- 1,2,3,4-Tetrahydropyrimidines
Synthesis
- from Like Ring Skeletons
– 4,4-dimethyl-2-oxo-6-styryl der. from 2-oxo-4,4,6-trimethyl der. and benzaldehyde 283
– 5-fluorouracils from uracils and fluorine 624 (3104)
– 6-morpholinothiocarbonyl-2-oxo der. from 6-methyl-2-oxo-der. sulfur, and morpholine 276
– 6-morpholinothiocarbonyl-2-thiono der. from 6-methyl-2-thiono der., sulfur, and morpholine 276
– 2-oxo der. from 4-alkoxy-2-oxohexahydropyrimidines and acetic anhydride 270
– 2-oxo der. from 4-hydroxy-2-oxohexahydropyrimidines and acetic anhydride 270
– 2-oxo-6-(4-methyl-2-oxo-hexahydro-4-pyrimidyl-methyl) der. from 6-methyl-2-oxo der. and acid 272, 282
– 2-oxo-5-(2-oxohexahydro-4-pyrimidyl) der. from 2-oxo der. and 4-hydroxy(alkoxy)-2-oxohexahydropyrimidines 269
– 2-oxo-6-tribromomethyl der. from 6-methyl-2-oxo der. and bromine 284
- of the Ring Skeleton
– 1,3-dialkyl-2-oxo der. from 4-oxo-2,3,5-trialkyltetrahydro-1,3,5-oxadiazines and acid 249
– 2-imino der. from 1-alkenyl ketones and guanidines 289
– 2-oxo der. by α-ureidoalkylation of aldehydes or ketones 270
– 2-oxo der. from 2-alkenals and ureas 289
– 2-oxo der. from 1-alkenyl ketones and ureas 289
– 2-oxo der. from alkoxymethyl-ureas and 1-alkynes 286
– 2-oxo der. from 3-hydroxy-alkanals and ureas 289
– 2-oxo der. from *N*-(3-hydroxy-1-alkenylureas and acid 245
– 2-thiono der. from 1-alkenyl ketones and thioureas 289
– 2-thiono der. from alkoxy-methyl-thiourea and 1-alkynes 286
– 2-thiono der. by α-thio-ureidoalkylation of aldehydes or ketones 274
Reactions
- Fusion of New Rings
– 5-acetyl-2-oxo der. + hydroxylamine + base 290
– 5-acetyl-2-oxo der. + phenylhydrazines + acid 290
– 6-alkylamino-1,3-dimethyl-uracils + nitrosobenzenes 817 (3313)
– 6-amino-1,3-dimethyl-6-nitrosouracids + formamides + phosphoryl chloride 67 (2655)
– 6-benzylidenehydrazino-3-methyl uracils, thermal cyclization 300
– 6-methyl-2-oxo der. + sulfur + dimethylformamide (or tetramethylurea) 276
– 6-methyl-2-thiono der. + sulfur + dimethylformamide (or tetramethylurea) 276
– 2-oxo-6-styryl der. + formaldehyde + primary amines 283
– 6-styryl-2-thiono der. + formaldehyde + primary amines 283
- Retention of the Ring Skeleton
– 6-methyl-2-oxo der. + acetone + acid 284
– 6-methyl-2-oxo der. + bromine 284
– 6-methyl-2-oxo der. + sulfur + morpholine 276
– 6-methyl-2-thiono der. + acetone + acid 284
– 6-methyl-2-thiono der. + sulfur + morpholine 276
– 2-oxo der. + 4-alkoxy-2-oxo-hexahydropyrimidines 269
– 2-oxo der., catalytic hydrogenation 276
– 2-oxo der. + 4-hydroxy-2-oxohexahydropyrimidines 269
– 2-thiouracil, *S*-aminomethylation by Mannich reaction 741

- Hexahydropyrimidines
see also: Barbituric Acids
Synthesis
- from Like Ring Skeletons
– 4-alkylthio-2-oxo der. from 4-alkoxy-2-oxo der. and alkylmercaptans 264
– 4-alkylthio-2-oxo der. from 4-hydroxy-2-oxo der. and alkylmercaptans 264
– 4-alkylthio-2-oxo der. from 2-oxo-4-ureido der. and alkylmercaptans 264
– 4-arylthio-2-oxo der. from 4-alkoxy-2-oxo der. and arylmercaptans 264
– 4-arylthio-2-oxo der. from 4-hydroxy-2-oxo der. and arylmercaptans 264
– 4-arylthio-2-oxo der. from 2-oxo-4-ureido der. and arylmercaptans 264
– 4-chloro-2-oxo der. from 4-hydroxy-2-oxo der. and thionyl chloride 270
– *cis*-4,6-dimethyl-2-oxo der. 368 (2894)
– 4-(2,6-dioxocyclohexyl)-2-oxo der. from 2-oxo-4-ureido der. and 1,3-dioxocyclohexanes 265
– 2,4-dioxo der. from 4-hydroxy-2-oxo der. and oxygen or hydrogen peroxide 280
– 2,4-dioxo-6-hydroxy der. from 6-chloro der. by hydrolysis 237 (2820)
– 4-(hydroxyphenyl)-2-oxo der. from 2-oxo-6-(4-methyl-2-oxo-hexahydro-4-pyrimidylmethyl)-1,2,3,4-tetrahydropyrimidines and phenols 267, 282
– 4-(hydroxyphenyl)-2-oxo der. from 2-oxo-4-ureido der. and phenols 265
– 4-(hydroxyphenyl)-2-thiono der. from 2-thiono-4-ureido der. and phenols 265
– 2-oxo der. from 4-alkoxy-2-oxo der. and formic acid 276
– 2-oxo der. from 4-alkoxy-2-oxo der. by catalytic hydrogenation 276
– 2-oxo der. from 4-hydroxy-2-oxo der. and formic acid 276
– 2-oxo der. from 4-hydroxy-2-oxo der. by catalytic hydrogenation 276
– 2-oxo der. from 2-oxo-1,2,3,4-tetrahydropyrimidines by catalytic hydrogenation 276
– 2-oxo-4-ureido der. from 4-hydroxy-2-oxo der. and urea 264
- of the Ring Skeleton
– 6-alkoxy-4-alkyl-2-oxo der. from 2*H*-alkanals, ureas, and alcohols 262
– 6-alkoxy-4-alkyl-2-thiono der. from 2*H*-alkanals, thioureas, and alcohols 262
– 4-alkoxy-2-oxo der. from 2-alkenals, ureas, and alcohols 289

– 4-alkyl-6-hydroxy-2-imino der. from 2*H*-alkanals and guanidines 262
– 4-alkyl-6-hydroxy-2-oxo der. from 2*H*-alkanals and ureas 262
– 4-alkyl-6-hydroxy-2-thiono der. from 2*H*-alkanals and thioureas 262
– 1,3-bis[2,2-dinitropropyl]-5-hydroxy der. 732
– 6-chloro-2,4-dioxo der. from *N*-alkylalkanimines and chlorocarbonyl isocyanate 237 (2820)
– 2-cyanoimino der. from dimethyl *N*-cyanocarbonimidodithioate and 1,3-diaminopropanes 821 (3328)
– 4-dialkylamino-2,6-dioxo-1,3-diphenyl der. from *N,N*-dialkylenamines and phenyl isocyanate 342
– 1,3-dibenzyl-2-phenyl der. from 1,3-bis[benzylamino]-propanes and benzaldehydes 736
– 2,2-dichloro-5,5-dimethyl-4,6-dioxo der. 202
– 6,6-dimethyl-2-oxohexahydropyrimidine(4-spiro-4)2-oxo-6-phenylhexahydropyrimidines
– 2,4-dioxo der. from alkoxymethylureas and ketenes 287
– 4-hydroxy-2-oxo der. from 1-alkenyl ketones and ureas 289
– 2-oxo der. from 3-alkoxycarbonylaminopropanals, ammonia or primary amines, and hydrogen/Raney nickel 279
– 2-oxo der. from 1,3-bis[alkoxycarbonylamino]-propanes 286
– 2-oxo der. from 3-ureidopropanals, ammonia or primary amines, and hydrogen/Raney nickel 279
– 2-oxohexahydropyrimidine-(4-spiro-4)-2-oxohexahydropyrimidines 284, 291
– 2-oxo-4-ureido der. from alkanals and urea 264, 265
– 2-thiono der. from *N*-(1-alkoxymethyl)-thioureas and alkenes 286
– 2-thionohexahydropyrimidine(4-spiro-4)-2-thionohexahydropyrimidines 284, 291

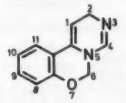
Reactions

- Fusion of New Rings
– 4-(2,6-dioxocyclohexyl)-2-oxo der. + aldehydes + acid 249
– 4-(2-hydroxyphenyl)-2-oxo der. + aldehydes 250, 265
– 4-(2-hydroxyphenyl)-2-thiono der. + aldehydes 265
– 1-hydroxymethyl-2-oxo der. + α-branched alkanals + acid 278
– 2-oxo-4-ureido der. + aldehydes + acid 265

- Retention of the Ring Skeleton
– 4-alkoxy-2-oxo der. + acetic anhydride 270
– 4-alkoxy-2-oxo der. + 2*H*-alkanals + acid 266
– 4-alkoxy-2-oxo der. + mercaptans + acid 264
– 4-alkoxy-2-oxo der. + formic acid 276
– 4-alkoxy-2-oxo der. + hydrogen/Raney nickel 276
– 4-alkoxy-2-oxo der. + 2-oxo-1,2,3,4-tetrahydropyrimidines 269
– 4-chloro-2-oxo der. + dialkyl phosphites 270
– 1-hydroxymethyl-2-oxo der. + phosphorus(III) halides 280
– 4-hydroxy-2-oxo der. + acetic anhydride 270
– 4-hydroxy-2-oxo der. + 2*H*-alkanals + acid 266
– 4-hydroxy-2-oxo der. + mercaptans + acid 264
– 4-hydroxy-2-oxo der. + dialkyl phosphites + acid 269
– 4-hydroxy-2-oxo der. + formic acid 276
– 4-hydroxy-2-oxo der. + hydrogen/Raney nickel 176
– 4-hydroxy-2-oxo der. + nucleophilic compounds, tabulation of types 264
– 4-hydroxy-2-oxo der. + 2-oxo-1,2,3,4-tetrahydropyrimidines 269
– 4-hydroxy-2-oxo der. + hydrogen sulfide 263
– 4-hydroxy-2-thiono der. + nucleophilic compounds, tabulation of types 264
– 2-oxo-4-ureido der., catalytic hydrogenation 276
– 2-oxo-4-ureido der. + dimedone + acid 265
– 2-oxo-3-ureido der. + phenols + acid 265
– 2-thiono-4-ureido der. + phenols + acid 265
– 2,4,6-trioxo der., *N*-aminomethylation by Mannich reaction 740

- Ring-Cleavage Reactions
– 2,4-dioxo der., hydrolysis 280

● **Pyrimido[3,4-*c*][1,3]benzoxazine**



2*H*,6*H*–

- 1,3,4,11b-Tetrahydro-2*H*,6*H*-pyrimido[3,4-*c*][1,3]benzoxazines

Synthesis

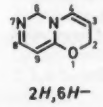
- of the Ring Skeleton
– 4-oxo der. from 4-(2-hydroxyphenyl)-2-oxohexahydropyrimidines and aldehydes 250
– 4-thiono der. from 4-(2-hydroxyphenyl)-2-thionohexahydropyrimidines and aldehydes 265

- 1,3,4,8,9,10,11,11b-Octahydro-2*H*,6*H*-pyrimido[1,6-*c*][1,3]-benzoxazines

Synthesis

- of the Ring Skeleton
– 4,11-dioxo der. from 4-(2,6-dioxocyclohexyl)-2-oxohexahydropyrimidines and aldehydes 249

● **Pyrimido[4,3-*b*][1,3]oxazine**



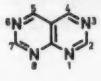
2*H*,6*H*–

- Hexahydro-2H,6H-pyrimido[4,3-*b*][1,3]-oxazines

Synthesis

- of the Ring Skeleton
– 2-chloro-4,8-diisopropyl-6-oxo-3,3,9,9-tetramethyl der. 263

● **Pyrimido[4,5-*d*]pyrimidine**

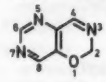


- Decahydropyrimido[4,5-*d*]pyrimidines

Synthesis

- of the Ring Skeleton
– 2,7-dioxo der. from 2*H*,2*H*-alkanals and *N,N'*-disubstituted ureas 265
– 2,7-dioxo der. from alkoxymethylureas and 1-alkynes 286
– 2,7-dioxo der. from 1-hydroxy-2-hydroxymethyl-3-oxobutane and ureas 291
– 2,7-dioxo der. from 2-oxo-4-ureidohexahydropyrimidines and aldehydes 265
– 2,7-dithiono der. from alkoxymethyl-thiourea and 1-alkynes 286

● **Pyrimido[4,5-*e*]-1,3-oxazine**



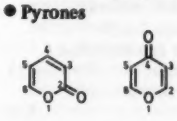
2*H*–

- 3,4-Dihydro-2*H*-pyrimido[4,5-*e*]-1,3-oxazines

Synthesis

- of the Ring Skeleton
– 3-alkyl-8-hydroxy der. from 4,5-dihydroxypyrimidines, formaldehyde, and alkylamines 729

● **Pyrones**



2– 4–

- 2-Pyrones

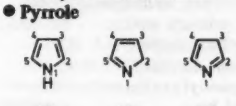
Synthesis
– – from 2-alkenals and chloroketene dimethyl acetal 236 (2817)
– – from 1-alkenyl ketones and chloroketene dimethyl acetal 236 (2817)
– – from 3-chloro-2,2-dimethoxy-2,3-dihydro-4*H*-pyrans and base 236 (2817)
– 3,4-diaryl-2-pyrones from pyridinium carbonylmethylids and diarylcyclopropenones 480
– tetraaryl-2-pyrones from tetraarylcyclopentadienones and cerium(IV) ammonium nitrate 349
– tetraphenyl-2-pyrones from tetraphenylcyclopentadienones and cerium(IV) ammonium nitrate/water 564 (3093)

- 4-Pyrones

Synthesis
– 2,3,5,6-bis[trimethylene]-4-pyrone 58 (2618)

Reactions
– 5-hydroxy-2-hydroxymethyl-4-pyrone + formaldehyde + taurine 729
– 5-hydroxy-2-hydroxymethyl-4-pyrone (kojic acid) + formaldehyde + amino-acids 729

● **Pyrrole**



1*H*– 2*H*– 3*H*–

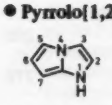
- Pyrroles

Synthesis

- from Like Ring Skeletons
– – from *N*-phenacyl-2,5-dihydropyrrole by irradiation 230 (2791)
– 1-(1-alkenyl)-pyrrole-2-carboxylic

acids from methyl pyrrole-2-carboxylate (potassio derivative) and oxiranes 184 (2761)
– 2-carboxy-1-(2-hydroxy-2-phenylethyl)-pyrrole 184 (2761)
– 1-methyl-2-styryl- and 2,5-distyryl-1-methylpyrrole from 1-methylpyrrole, styrene, and palladium(II) acetate 530
- *of the Ring Skeleton*
– – from dialkylaminoethenyl phenyl ketones, photochemically 66 (2651)
– 3-acylpyrroles from 1-alkenyl ketones and tosylmethyl isocyanide 562 (3085)
– 3-alkoxycarbonylpyrroles from alkyl 2-alkenoates and tosylmethyl isocyanide 562 (3085)
– 3-cyanopyrroles from 2-alkenenitriles and tosylmethyl isocyanide 562 (3085)
– 2-cyanopyrroles from tetrazolopyridines by gas-phase pyrolysis 135
– 3,4-diacylpyrroles from 2-amino-1-alkenyl ketones, electrochemically 503 (3010)
– 3,4-dialkoxycarbonylpyrroles from 3-amino-2-alkenoic acid esters, electrochemically 503 (3010)
– 2,5-disubstituted 3,4-dimethoxycarbonylpyrroles from 2-acylaminoalkanoic acids and dimethyl acetylenedicarboxylate 473
– 1-ethoxycarbonyl-3-formylpyrrole 422
- **2,3-Dihydropyrroles**
Synthesis
- *of the Skeleton*
– – from 1,3-oxazolium-5-oxides and alkenes 474
– 4-alkoxycarbonyl-5-amino-1-tosyl der. from 1-tosylaziridines and alkyl cyanoacetates 546
– 1-methyl-2-oxo der. from *N*-acyl-*N'*-(1-alkenyl)-*N,N'*-dimethylhydrazines and base 560 (3079)
- **2,5-Dihydropyrroles**
Synthesis
- *of the Ring Skeleton*
– – from aziridines and C=C double-bond systems 474
– 1-aryl-2,3,4,5-tetraalkoxycarbonyl der. from 1-aryl-2,3-dialkoxycarbonylaziridines, thermally 470
- **3,4-Dihydro-2*H*-pyrroles**
Synthesis
- *from Like Ring Skeletons*
– – from 1-acyl-2-oxopyrrolidines 440 (2981)
- **Pyrrolidines**
Synthesis
- *from Like Ring Skeletons*
– 1-ethenyl-2-oxopyrrolidine (*N*-vinylpyrrolidone) 439 (2979)
- *of the Ring Skeleton*
– 2-aminocarbonyl-5-cyano der. from 1,4-diketones, hydrogen cyanide, and primary amines 735
– 1-aryl-5,5-diethoxycarbonyl-2-oxo der. from diethyl *N*-(3-bromopropanoyl)-anilinomalonates and base 339
– 1-[2-(2-ethoxyphenoxy)-ethyl]-2-oxo der. 538
Reactions
- *Retention of the Ring Skeleton*
– – aminomethylation by Mannich reaction 727

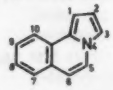
● **Pyrrolo[1,2-*a*]imidazole**



1*H*–

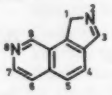
Synthesis
- *of the Ring Skeleton*
– 5-benzoyl-7-ethoxycarbonyl der. from imidazolium phenacyclids and ethyl propynoate 475

● **Pyrrolo[2,1-*a*]isoquinoline**



- **Pyrrolo[2,1-*a*]isoquinolines**
Synthesis
- *of the Ring Skeleton*
– – from isoquinolinium alkylids and alkynes 473
- **1,2,3,5,6,10a-Hexahydropyrrolo-[2,1-*a*]isoquinolines**
Reactions
- *Ring-Cleavage Reactions*
– – by *N*-oxidation-reductive cleavage 543

● **Pyrrolo[3,4-*h*]isoquinoline**



1*H*–

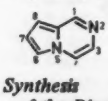
- **2,3,4a,4,5,9b-Hexahydro-1*H*-pyrrolo-[3,4-*h*]isoquinolines**
Synthesis
- *of the Ring Skeletons*
– 2-substituted 1,3-dioxo der. from 4-ethenylpyridine and *N*-substituted maleimides 630 (3127)

● **Pyrrolo[2,1-*c*][1,4]oxazine**

1*H*–

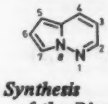
- **3,4-Dihydro-1*H*-pyrrolo[2,1-*c*][1,4]-oxazines**
Synthesis
- *of the Ring Skeleton*
– 1-oxo-3-phenyl der. 184 (2761)

● **Pyrrolo[1,2-*a*]pyrazine**



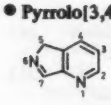
Synthesis
- *of the Ring Skeleton*
– – from pyrazinium phenacylides and dialkyl acetylenedicarboxylates 475
– 7,8-diphenyl-6-hydroxy der. from pyrazines and diphenylcyclopropenone 120 (2704)

● **Pyrrolo[1,2-*b*]pyridazine**



Synthesis
- *of the Ring Skeleton*
– 7-cyano der. from pyridazinium 1-dicyanomethylids and alkynes 475
– 5,6-diphenyl-7-hydroxy der. from pyridazines and diphenylcyclopropenone 120 (2704)

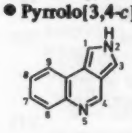
● **Pyrrolo[3,4-*b*]pyridine**



5*H*–

- **6,7-Dihydro-5*H*-pyrrolo[3,4-*b*]-pyridines**
Synthesis
- *from Like Ring Skeletons*
– 7-unsubstituted der. from 7-oxo der. and lithium alanate 609
- *of the Ring Skeleton*
– 2,4-diaryl-7-oxo der. from 1-alkyl-4-benzylidene-2,3-dioxopyrrolidines and 1-phenacylpyridinium bromides 609
– 7-oxo der. from 1-alkyl-4-benzylidene-2,3-dioxopyrrolidines, ethyl acetoacetate, and aqueous ammonia 609
- **1,4,6,7-Tetrahydro-5*H*-pyrrolo-[3,4-*b*]pyridines**
Synthesis
- *of the Ring Skeleton*
– 4-aryl-7-oxo der. from alkyl 3-aminoalkenoates and 4-benzylidene-2,3-dioxopyrrolidines 609

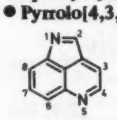
● **Pyrrolo[3,4-*c*]quinoline**



2*H*–

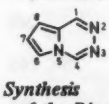
Synthesis
- *of the Ring Skeleton*
– – from 3-formylpyrroles and phenylhydrazine 500 (2998)

● **Pyrrolo[4,3,2-*de*]quinoline**



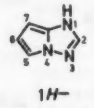
- **1,3,4,5-Tetrahydropyrrolo-[4,3,2-*de*]quinolines**
Synthesis
- *of the Ring Skeleton*
– – from 3-cyanomethyl-4-nitroindole 750

● **Pyrrolo[1,2-*d*][1,2,4]triazine**



Synthesis
- *of the Ring Skeleton*
– – from 2-(1-acylhydrazono-alkyl)-pyrroles and base 698 (3212)

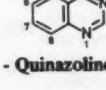
● **Pyrrolo[1,2-*b*][1,2,4]triazole**



1*H*–

- **1H-Pyrrolo[1,2-*b*][1,2,4]triazoles**
Synthesis
- *of the Ring Skeleton*
– – from 1-phenacyl-1,2,4-triazolium bromides and weak base 414

● **Quinazoline**



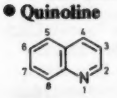
- **Quinazolines**

Synthesis
- of the Ring Skeleton
– 4-amino der. from 2-amino-benzamide, *N,N*-dimethyl-chloromethaniminium chloride, and ammonia or primary amines 237 (2821)
– 4-hydroxy-2-sulfonylamino der. from 2-aminobenzamide and *N*-(chloro-methylthio-methylene)-sulfonamides 326 (2879)
Reactions
- Transformation of the Ring Skeleton
– 4-chloro der. + hydrazine hydrate 374 (2921)

- 1,2-Dihydroquinazolines
Synthesis
- of the Ring Skeleton
– 4-halo-2-oxo der. from 2-cyanophenyl isocyanates and hydrogen halide 192
– 4-halo-2-thiono der. from 2-cyanophenyl isothiocyanates and hydrogen halide 192
– 2-oxo der. from *N*-acyl-*N'*-arylureas and polyphosphoric acid 325 (2877)

- 1,2,3,4,5,6,7,8-Octahydroquinazolines
Synthesis
- of the Ring Skeleton
– 3-benzyl-2-oxo der. 766
– 2-oxo der. by α-ureido-alkylation reactions 274
– 2-oxo-1,2,3,4,5,6,7,8-octahydro-quinazoline(4-spiro)cyclohexanes from cyclohexanone and ureas 281
– 2-thiono der. by α-thioureido-alkylation reactions 275
– 2-thiono-1,2,3,4,5,6,7,8-octahydro-quinazoline(4-spiro)cyclohexanes from cyanohexanone and thioureas 281

● Quinoline



- Quinolines
Synthesis
- from Like Ring Skeletons
– acetylquinolines from quinoline by radical acetylation 15
– alkylquinolines from quinolines by radical alkylation 13
– (2-aminoethyl)-quinolines from methylquinolines, formaldehyde, and dialkylamines 734
– 2- and 4-(*N*-formyl-*N*-methylamino-methyl)-quinolines from quinolines, dimethylformamide, and peroxy compounds 18
– 7-chloro-4-(3-dialkylamino-4-hydroxyanilino)-quinolines from 4,7-dichloroquinoline and 4-amino-2-dialkylaminophenols 722
– 5-dialkylamino-8-methoxyquino-lines from 8-methoxyquinoline and *N*-chlorodialkylamines 5
– 6,7-dimethoxy-3-ethoxycarbonyl-quinoline 48
– dimethylaminocarbonylquino-lines from quinolines, dimethyl-formamide, and peroxy compounds 18
– 2-(1,4-dioxanyl)-quinolines from quinolines, 1,4-dioxan, iron(II) sulfate, and *t*-butyl hydroperoxide 16
– 2-(1-hydroxyalkyl)-quinolines from 2-cyanoquinoline, alcohols, and oxygen(+ irradiation) 236 (2818)
– 4-(1-hydroxyethyl)-quinoline 17
– hydroxymethylquinolines from quinolines, methanol, and oxidizing agents 17
– quinoline 1-oxide 68 (2658)
- of the Ring Skeleton
– – from 2-anilinoethyl ketones, polyphosphoric acid, and trityl chloride 767
– – from *N*-phenyl-2-propenimines, thermally 69 (2662)
– 5-alkoxycarbonyl-3-phenyl-quinolines from alkyl 3-aminobenzoates and 1,3-dialkoxy-2-hydroxy-2-phenyl-propanes 505 (3016)
– 2-dialkylaminoquinolines from *N,N*-dialkyl-*N'*-phenyl-2-alkynamidines and polyphosphoric acid 67 (2656)
– 4-diethylaminoquinolines from 4-oxo-4*H*-3,1-benzoxazines and 1-diethylamino-1-alkynes 237 (2819)
– 6,7-dimethoxy-3-ethoxy-carbonyl-4-ethoxycarbonyl-methylquinoline 48
– 2-morpholinoquinolines from *N*-phenylchloromorpholino-methanimines and 2-propy-nylmagnesium bromide 67 (2656)
Reactions
- Retention of the Ring Skeleton
– – radical acetylation 15
– – radical alkylation 13
– 2-cyanoquinoline + alcohols + oxygen + irradiation 236 (2818)
– methylquinolines, α-(amino-methylation) by Mannich reaction 734
– ring-A hydroxyquinolines, aminomethylation by Mannich reaction 730

- Quinolinium Salts
Synthesis
- from Like Ring Skeletons
– 1-aminoquinolinium mesitylene-sulfonates from quinolines and *O*-mesitylsulfonylhydroxyl-amine 549 (3036)
- of the Ring Skeleton
– – from 2-anilinoethyl ketones and acid 767

- Quinolinium Ylids
Synthesis
– 1-phenyliminoquinolinium ylid 471

- 1,4-Dihydroquinoline
Synthesis
- of the Ring Skeleton
– 3-carboxy-4-oxo der. from diethyl *N*-arylaminomethylene-malonates and phosphorus pentoxide 325 (2876)
– 6,7-dimethoxy-3-ethoxycarbonyl-4-ethoxycarbonylmethyl der. 48

- 3,4-Dihydroquinolines
Synthesis
- of the Ring Skeleton
– 3-diethylaminocarbonyl-4-oxo der. from 4-oxo-4*H*-3,1-benzoxazines and 1-diethyl-amino-1-alkynes 237 (2819)

- 1,2,3,4-Tetrahydroquinolines
Synthesis
- of the Ring Skeleton
– – from *N*-chloro-3-phenyl-propylamines 9
– 1-alkoxycarbonyl-3-dialkyl-aminomethyl-4-oxo der. from 2-aminoaryl-ketonic Mannich bases 766
– 2,4-dioxo-3-triphenylphosphoran-ylidene der. from 2,4-dioxo-1,2-dihydro 4*H*-1,3- benzoxazines and alkoxycarbonylmethylenetri-phenylphosphoranes 813 (3295)
– 4-oxo der. from 3-anilino-propanoic acids and poly-phosphoric acid 698 (3213)

- 1,2,3,4,5,6,7,8-Octahydroquinolines
Reactions
- Transformation of the Ring Skeleton
– 1-acetyl der. + butyl nitrite + acid 313

● Quinones
- General
Synthesis
– – from arenes and cerium(IV) ammonium nitrate 206
– – from hydroquinones and cerium(IV) ammonium nitrate 351, 369 (2898)
Reactions
– aminoquinones + *t*-butyl hypochlorite 49

- Anthraquinones
Synthesis
– 1-aminoanthraquinones from 1-chloroanthraquinones and *N*-substituted carboxamides 432 (2948)
– 9,10-anthraquinone 352
– 1-amino-4-hydroxyanthraquinones from phthalic anhydride and 4-aminophenols (or their benzoates) 802 (3246)
– 1,4-anthraquinones from 1,2-bis[methylene]-cyclohexadienes and *p*-benzoquinone 416
– 9,10-anthraquinones from 1,4-naphthoquinones, 2-alkenals, and ethoxymagnesium bromide 369 (2897)

- *o*-Benzoquinones
Synthesis
– 3,5-di-*t*-butyl-*o*-benzoquinone 614
– 4,5-methylenedioxy-*o*-benzo-quinones from 1,2-dimethoxy-4,5-methylenedioxybenzenes and nitric acid 117 (2689)
Reactions
– 3,5-di-*t*-butyl-*o*-benzoquinone, irradiation 614

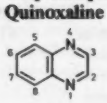
- *p*-Benzoquinones
Synthesis
– – from benzenes and (1.) thallium(III) trifluoroacetate, (2.) peroxytrifluoroacetic acid 231 (2793)
– 2-amino-3-chloro-*p*-benzo-quinones from 2-amino-*p*-benzoquinones and *t*-butyl hypochlorite 49
– 5-*t*-butyl-2,3-dihalo-*p*-benzo-quinones from di-*t*-butyl-*p*-benzoquinones by a four-step halogenation-oxidation sequence 688 (3171)
Reactions
– – with 2-alkenals + ethoxymagne-sium bromide 369 (2897)
– *p*-benzoquinone + 1,2-bis-[methylene]-cyclohexadienes 416

- Diphenoquinones
Synthesis
– – from 2,6-disubstituted phenols and periodic acid 357

- Naphtoquinones
Synthesis
– – from naphthalene and cerium(IV) ammonium nitrate 352
– 2-(1-aminoalkyl)-3-hydroxy-1,4-naphthoquinones from 2-hydroxy-1,4-naphthoquinone, acetaldehyde, and primary or secondary amines 734

– 2-amino-3-chloro-1,4-naphthoquinone 49
– 1,4-naphthoquinones from *p*-benzoquinones, 2-alkenals, and ethoxymagnesium bromide 369 (2897)
– 1,4-naphthoquinones from naphthalenes and thallium(III) trifluoroacetate 231 (2793)
Reactions
– 2-hydroxy-1,4-naphthoquinone + acetaldehyde + alkylamines or dialkylamines 734
– 1,4-naphthoquinones + 2-alkenals + ethoxymagnesium bromide 369 (2897)
– 1,4-naphthoquinone + 1,2-bis-[methylene]-cyclohexadienes 416
- Phenanthrenequinones
Synthesis
– phenanthrene-9,10-quinone 352
- Stilbenequinones
Synthesis
– stilbene-3,4-quinones from 3,4-dihydroxystilbenes and silver carbonate 499 (2995)
- Miscellaneous Types
Synthesis
– cyclobutabenzene-1,2-quinone 212
– 6,11-dihydroxy-1-methoxynaphthacene-5,12-quinones from 2-ethoxycarbonyl-8-methoxy-1,4-naphthoquinones and phthalide anion 319 (2854)
– indole-4,7-quinones from 2-(1-alkenyl)-3-azido-*p*-benzoquinones, thermally 816 (3309)
– naphthacene-5,12-quinones from 1,2-bis[methylene]-cyclohexadienes and 1,4-naphthoquinone 416

● Quinoxaline



Synthesis
- from Like Ring Skeletons
– acyl der. from quinoxaline, aldehydes, iron(II) sulfate, and *t*-butyl hydroperoxide 15
– 2-aminocarbonyl der. 19
– 2-(1,4-dioxanyl) der. 16
– 2-(1,3-dioxolan-4-yl) der. 16
– 2-(1-ethoxyethyl) der. 16
– 2-(tetrahydrofuran-2-yl) der. 16
Reactions
- Retention of the Ring Skeleton
– – radical *C*-arylation 15

● Reductones
- 3-Oxo-enediols
Synthesis
– 8,9-dihydroxy-7-oxo-1,3,8-decatriene 399

● Sapogenins
Synthesis
– 1,7-diacetoxydiosgenin 572
Reactions
– 27-*O*-tosylpseudodiosgenin + potassium azide 84

● Selenocyanates
Reactions
– 2-selenocyanatobenzoyl chloride + hydrogen chloride 192

● Selenoethers
Synthesis
– 4-aminobenzyl phenyl selenides from benzeneselenol, formaldehyde, and anilines 742

● Selenols
Reactions
– benzeneselenol, *Se*-aminomethylation by Mannich reaction 742

● Selenophene

- Selenophenes
Synthesis
- from Like Ring Skeletons
– 2-styryl- and 2,5-distyryl der. from selenophene, styrene, and palladium(II) acetate 530

● Semiacetals and Derivatives
- *O,O*-Semiacetal Acylates
Synthesis
– – from alkyl ethers and lead(IV) acetate 576
- *O,S*-Semiacetal *O*-Acylates
Synthesis
– – from alkyl sulfides and lead(IV) acetate 576
- *S,S*-Semiacetal Acylates
Synthesis
– – from 1-chloroalkyl sulfides and potassium thiocarboxylates 812 (3293)
– – from mercaptans and *S*-(1-chloroalkyl)-thiocaroxylates 812 (3293)
- *O*-Semiacetal Halides
Reactions
– bis[1-chloro-2-methylpropyl] ether + urea 263
– (chloromethoxy)-alkanes + sodium alkylnitramides 302
– semiacetal chlorides + dimethylformamide + carbonyl chloride + urea 258
- *S*-Semiacetal Halides
Synthesis
– 1-chloro-1-methylthiocyclopropanes from alkenes and chloro-methylthiocarbene 210

● Semicarbazones
Reactions
- Cyclization Reactions
– dialkyl ketone semicarbazones + lead(IV) acetate 322 (2868)
- Regeneration of the Carbonyl Compounds
– – with cerium(IV) ammonium nitrate 349

● Silanes
- 1-Alkenylsilanes and Derivatives
Synthesis
– 3-ethyl-2-trimethylsilyl-2-pentene 310
– 2- and 3-trimethylsilyl-2-pentenes from 3-diethylboryl-2-trimethylsilyl-2-pentene 310
- 2-Alkenylsilanes and Derivatives
Reactions
– 3,6-bis[trimethylsilyl]-1,4-cyclohexadiene + base 431 (2943)
- Alkylsilanes Types $RSiH_2X$, $RSiHX_2$, $RSiX_3$
Synthesis
– alkyltrichlorosilanes from 1-alkenes and trichlorosilane 372 (2913)
– 1-triethoxysilylalkanes from 1-alkenes and triethoxysilane 372 (2913)
Synthesis
– arylethynyltrimethylsilanes from iodotrimethylsilylacetylene and arylcopper 549 (3034)
– 3-aryl-5-trimethylsilylethynylpyrazoles from aryl trimethylsilylbutadiynyl ketones and hydrazine 47
– 1-pentafluorophenyl-2-triethylsilylacetylene 318 (2847)
- 1-Alkynylsilanes and Derivatives
Reactions
– 3-aryl-5-trimethylsilylethynylpyrazoles + aqueous base 47
– 1,ω-bis[triethylsilyl]-polyynes, alkaline hydrolysis 805 (3259)
- Arylsilanes, Di-, Tri-, Tetraarylsilanes and Derivatives
Synthesis
– aryltrialkylsilanes from aryldialkylsilanes and alkyl halides 558 (3071)
– bis[triphenylsilyl] carbonate 234 (2806)
– dialkyldiarylsilanes from alkyldialkylsilanes and alkyl halides 558 (3071)
– diphenylsilane 385
– *Si, Si*-disubstituted bis[*N,N*-bis(trimethylsilyl)-4-aminophenyl]-silanes 223
– *Si,Si*-disubstituted bis[4-phthalimidophenyl]-silanes 223
– trimethylsilylnaphthalenes from trimethylsiloxynaphthalenes and chlorotrimethylsilane/sodium 558 (3069)
– triphenylsilane 385
Reactions
– alkyldiarylsilanes + alkyl halides + isopropylmagnesium chloride 558 (3071)
– alkyldiarylsilanes + chlorotrimethylsilane + alkylmagnesium halides 558 (3070)
– chlorotriphenylsilane, electrochemical reduction 385
– dialkylarylsilanes + alkyl halides + isopropylmagnesium chloride 558 (3071)
– dichlorodiphenylsilane, electrochemical reduction 385
– triphenylsilane + 2-oxo-1,3-dioxolane + nickel catalysts 234 (2806)
- Disilanes and Derivatives
Synthesis
– unsymmetrical diphenyltetraalkyldisilanes from chlorotrimethylsilane and alkyldiarylsilanes 558 (3070)
– unsymmetrical disilanes from chlorotrimethylsilane, secondary or tertiary arylsilanes, and alkylmagnesium halides 558 (3070)
- Tetraalkylsilanes
Synthesis
– – from 1-alkenes and trialkylsilanes 372 (2913)
- Trialkylsilanes Type R_3SiH
Reations
– – with dialkyl carbonates in the presence of nickel catalysts 234 (2806)
- Trialkylsilanes Type R_3SiX
Synthesis
– alkoxy-*t*-butyldimethylsilanes from alcohols, *t*-butylchlorodimethylsilane, and imidazole 372 (2912)
– bis[trialkylsilyl] carbonates from dialkyl carbonates and trialkylsilanes (+ nickel catalysts) 234 (2806)
Reactions
– chlorotrimethylsilane + alkyldiphenylsilanes + alkylmagnesium halides 558 (3070)

– trimethylsilyl azide + carboxylic anhydrides 321 (2863)
– trimethylsilyl azide + dicarboxylic acid anhydrides 321 (2861)
– trimethylsilyl azide + perfluoroalkanoyl chlorides 321 (2862)

- Miscellaneous Types

Synthesis

– bis[trimethylsilyl]-acetic acid 558 (3072)
– tris[trimethylsilyl]-acetic acid 558 (3072)

● Silete

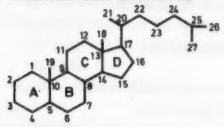
- Siletanes

Synthesis

- of the Ring Skeleton

– – from chloro-3-chloropropylsilanes and magnesium 437 (2971)
– siletane(1-spiro-1)siletane 438 (2971)

● Steroids and Relatives



- General

Synthesis

– α-acetoxyketo-steroids from keto-steroids and lead(IV) acetate 583
– 17-(3-dialkylamino-1-propynyl)-17-hydroxy-steroids from 17-ethynyl-17-tetrahydropyranyloxy-steroids, formaldehyde, and dialkylamines 732
– methoxy-steroids from hydroxy-steroids and dimethyl phosphite 115 (2677)
– 15-oxo-Δ^8-steroids from Δ^{14}-steroids and mercury(II) acetate/acetic acid 702 (3227)
– phenoxy-steroids from hydroxy-steroids and diphenyl phosphite 115 (2677)
– steroidal carboxamides from steroidal carboxylic acids, amines, and EEDQ 320 (2856)
– steroidal carboxamides from steroidal carboxylic acids, amines, and triphenyl phosphite/imidazole 320 (2856)

Reactions

– 17-ethynyl-17-hydroxy-steroids, *O*-protection and aminomethylation by Mannich reaction 732
– hydroxy-steroids, etherification with dimethyl or diphenyl phosphite 115 (2677)
– keto-steroids + lead(IV) acetate 583
– 3-oxo-Δ^4-19-norsteroids + oxygen 702 (3226)
– steroidal ketones, aminomethylation by Mannich reaction 711
– Δ^{14}-steroids + mercury(II) acetate/acetic acid 702 (3227)

- Androstanes

Reactions

– 16-aminomethylene-*epi*-androsterone + 6-aminouracil der. 822 (3333)
– 2-aminomethyl-3-oxo der. + bromine 773

- Androstenes

Synthesis

– 1,2,3,4-tetrahydro-*epi*-androsteno[17',16':4,5]pyrido[2,3-*d*]-pyrimidines from 16-aminomethylene-*epi*-androsterone and 6-aminouracil der. 822 (3333)

- Cholestanes

Synthesis

– 3β-hydroxy-5α,6α-epoxycholestane 156

- Cholestenes

Synthesis

– 3,7-diacetoxycholest-5-ene 573
– 3-methylenecholest-5-ene 56 (2610)

Reactions

– *O*-acetylcholesterol + lead(IV) acetate 573
– cholesterol + disuccinoyl peroxide/dimethylformamide + sodium hydrogen carbonate 156

- Estratrienes

Synthesis

– 17β-acetoxy-1-formyl-3-methoxy-estra-1,3,5(10)-triene 352
– 6,17-diacetoxy-4-methyl-1,3,5(10)-estratrienes from the 17-mono-acetoxy der. and cerium(IV) ammonium nitrate 601
– 3-hydroxy-6-oxo-1,3,5(10)-estratrienes from 3-oxo-Δ^4-19-norsteroids and oxygen 702 (3226)

Reactions

– 17β-acetoxy-3-methoxy-1-methylestra-1,3,5(10)-triene + cerium(IV) ammonium nitrate 352

- Pregnanes

Synthesis

– 21-acetoxy-11,20-dioxo-3α-hydroxy-5β-pregnane 585

- Pregnatrienes

Synthesis

– 21-methyl-19-norpregna-4,17,20-triene 32

- B-Seco-Steroids

Synthesis

– precalciferol 466

● Stilbenes

Synthesis

– from aryldiazomethanes and cerium(IV) ammonium nitrate 353
– from benzaldehydes and benzylidenetriphenylphosphoranes 295
– – from α,β-dihydrostilbene by metallation-demetallation 804 (3254)
– 3,4-dihydroxystilbenes from 3,4-dihydroxybenzaldehydes and phenylacetic acids 499 (2995)
– *trans*-4-diphenylaminostilbene 531
– *trans*-stilbenes from di-μ-chlorodichlorobis[styrene]-palladium(II) and benzenes 524
– *trans*-stilbenes from ethylene, benzenes, and palladium(II) acetate 526

● Styrenes

Synthesis

– – from 1-bromo-2-phenylethanes and aqueous base (+ quaternary aminium compounds) 449
– *o*-allylstyrene 149
– ω-chlorostyrene 532, 684 (3157)
– ω,ω-dichlorostyrene 532
– α,β,β-trifluoropolyhalostyrenes from iodotrifluoroethylene and polyhalophenylcopper 684 (3154)

Reactions

– ω-bromostyrene + copper(I) chloride 684 (3157)
– ω-bromostyrene + copper(I) cyanide 684 (3157)
– styrene + disuccinoyl peroxide 156

● Sulfenes

Synthesis

– methylsulfonylsulfene 211

Reactions

– methylsulfonylsulfene + phenol 211
– methylsulfonylsulfene + water 211
– sulfene + 1-pyrrolidino-1-alkenes 322 (2867)

● Sulfenic Acid Amides

Synthesis

– *N*-alkyl-*N*-arylthioarenesulfenamides from *N*-arylthioarenesulfenamides and (1.) butyllithium, (2.) alkyl halides or alkyl tosylates 229 (2785)
– *N*-alkylidenearensulfenamides from diaryl disulfides, ammonia, ketones, and silver nitrate 181 (2747)
– arenesulfenamides from diaryl sulfides, amines, and silver(I) salts 63 (2638)
– aryloxomethanesulfenamides from sodium arenecarbothioates and sodium hydroxylamine-*O*-sulfonate 556 (3063)
– arylphenyliminomethanesulfenamides from sodium *N*-phenylarenecarboximidates and sodium hydroxylamine-*O*-sulfonate 556 (3063)
– arylthionomethanesulfenamides from sodium arenecarbodithioates and sodium hydroxylamine-*O*-sulfonate 556 (3063)
– benzenesulfenamides from methyl benzenesulfenate and aminoboranes 555 (3059)
– 1-benzothiophene-2-sulfenamides from bis[1-benzothiophen-2-yl] disulfide, amines, and silver(I) salts 63 (2638)

Reactions

– *N*-alkyl-*N*-phenylthiobenzenesulfenamides + ethylmercaptan 229 (2784, 2785)
– *N*-phenylthiobenzenesulfenamide + activated 1-alkenes + benzyltrimethylaminium hydroxide 228 (2784)

● Sulfenic Acid Esters

Reactions

– methyl benzenesulfenate + aminoboranes 555 (3059)

● Sulfenic Acid Halides

- General

Reactions

– sulfenyl chlorides + trialkylboranes 659

- Alkanesulfenyl Halides

Reactions

– alkane-1,2-bis[sulfenyl chlorides] + α-methylene-carbonyl compounds 120 (2701)

- Arenesulfenyl Halides

Synthesis

– pentafluorobenzenesulfenyl chloride 52

Reactions

– benzenesulfenyl chloride + *O*-trimethylsilylenols 371 (2908)
– 4-methylbenzenesulfenyl chloride + 2-mercapto-1,3,4-oxadiazoles 322 (2864)
– 4-methylbenzenesulfenyl chloride + 2-mercapto-1,3,4-thiadiazole 322 (2865)

- Chlorocarbonylsulfenyl Chloride

Reactions

– – with alkylmercaptans 114 (2672)

● Sulfilimines

Synthesis

– – from *N*-tosylsulfilimines and sulfuric acid 182 (2749)
– *N*-acetyldialkylsulfilimines from dialkyl sulfides and *N*-bromoacetamide 322 (2865)

– *N*-tosylsulfilimines from thioethers and *O*-mesitylsulfonylhydroxylamines (4 steps) 692 (3186)

Reactions

– *N*-tosylsulfilimines + *O,O*-dialkyl-dithiophosphates 174 (2712)
– *N*-tosylsulfilimines + dithioacetic acid 174 (2713)
– *N*-tosylsulfilimines + sulfuric acid 182 (2749)

● Sulfines

Synthesis

– – from sterically hindered thioketones and ozone 617
– aryl-(arylthio)-sulfines from aryl arenedithiocarboxylates and ozone 617

Reactions

– – with ozone 617

● Sulfinic Acid Amides

Synthesis

– – from *N*-sulfinylphthalimides and amines 501 (3001)

● Sulfinic Acid Esters

Synthesis

– – from *N*-sulfinylphthalimides and alkoxide ion 501 (3001)
– ethyl alkanesulfinates from alkyl *t*-butyl sulfoxides, ethanol, and *N*-halosuccinimides 691 (3185)

● Sulfinic Acid Halides

Synthesis

– sulfinyl chlorides from chloromethyl sulfoxides and chlorine 691 (3183)

Reactions

– sulfinyl chlorides + diazomethane + alkali metal iodides 811 (3288)

● Sulfinic Acids

Reactions

– sodium sulfinates + aldehydes + carboxamides or lactams 742
– sodium sulfinates + aldehydes + sulfonamides 742

● Sulfinothioic Acid Esters

- *S*-Esters

Synthesis

– *S*-alkyl alkanesulfinates from dialkyl disulfides and oxygen + irradiation 811 (3289)

Reactions

– *S*-alkyl alkanesulfinothioates + 1-alkynes 233 (2803)
– *S*-alkyl alkanesulfinothioates + ethyl acrylate 233 (2803)

● Sulfones

- General

Synthesis

– 1-acylaminoalkyl sulfones from sodium sulfinates, aldehydes, and carboxamides or lactams 742

- 1-Alkenyl Sulfones

Synthesis

– – from 1,1-dimetallated methyl (or benzyl) phenyl sulfones and aldehydes or ketones 801 (3241)
– aryl styryl sulfones from arylsulfonylacetic acids, aromatic aldehydes, and ammonia or amines 727
– 1-formylamino-1-alkenyl 4-methylphenyl sulfones from isocyanomethyl 4-methylphenyl sulfone and aldehydes or ketones 62 (2634)

Reactions

– 1-formylamino-1-alkenyl 4-methylphenyl sulfones + sodium methoxide 688 (3172)
– phenyl styryl sulfones + benzaldehyde phenylnitrone 373 (2917)

- 2-Alkenyl Sulfones

Synthesis

– 4-chloro-2-butenyl phenyl sulfones from benzenesulfonyl chlorides, butadiene, and copper(II) chloride 233 (2802)

- Alkyl Aryl Sulfones

Synthesis

– alkylnitraminomethylaryl sulfones from *N*-alkyl-*N*-arylthiomethylnitramines and phthalomonoperoxoic acid 303
– 2-amino-2-arylethyl aryl sulfones from arylsulfonylacetic acids, aromatic aldehydes, and ammonia or amines 727
– aryl 1-(sulfonylamino)-alkyl sulfones from sodium sulfinates, aldehydes, and sulfonamides 742
– 2-chloroethyl phenyl sulfones from benzenesulfonyl chlorides, ethylene, and copper(II) chloride 233 (2802)
– 2-cyanoalkyl 4-methylphenyl sulfones from tosyl cyanide and alkenes (+ irradiation) 182 (2750)
– 1-ethoxycarbonylaminoalkyl 4-methylphenyl sulfones from ethyl carbamate, aldehydes, and 4-methylbenzenesulfinic acid 812 (3290)
– isocyanomethyl 4-methylphenyl sulfone 62 (2634)

- Dialkyl Sulfones

Synthesis

– alkyl alkylnitraminomethyl sulfones from *N*-alkyl-*N*-alkylthiomethylnitramines and phthalomonoperoxoic acid 303

- Miscellaneous Types

Synthesis

– 2,11-dithia[3.3]metacyclophane 2,2;11,11-bis-dioxides from the corresponsing sulfides and hydrogen peroxide 97
– phenyl bis[methylsulfonyl]-methanesulfonate 211

Reactions

– tosyl cyanide + alkenes + irradiation 182 (2750)

● Sulfonic Acid Amides

- General

Reactions

– – with formaldehyde and acid 257
– *N*-dichloromethylenesulfonamides + 2-aminobenzenethiol 323 (2870)
– *N*-dichloromethylenesulfonamides + 2-aminophenol 323 (2870)
– *N*-dichloromethylenesulfonamides + benzohydroximic acid 323 (2870)
– *N*-dichloromethylenesulfonamides + benzohydroximic acid amides 323 (2870)
– *N*-dichloromethylenesulfonamides + benzothiohydroximic acid 323 (2870)
– *N*-dichloromethylenesulfonamides + mercaptoacetic acid 323 (2870)

- Alkanesulfonamides

Synthesis

– *N*-(2-hydroxyalkyl)-alkanesulfonamides from alkanesulfonamides and 2-oxo-1,3-dioxolanes 625 (3108)

Reactions

– *NH*-alkanesulfonamides + 2-oxo-1,3-dioxolanes + base 625 (3108)

- Arenesulfonamides

Synthesis

– 2-aminobenzenesulfonamides from bis[2-nitrophenyl] disulfide and amines 182 (2748)
– *N*-(1-arylsulfonylalkyl)-arenesulfonamides from arenesulfonamides, aldehydes, and sodium arenesulfinates 742
– 2-diazoacetylbenzenesulfonamides from 2-diazoacetylbenzenesulfonyl chlorides and primary amines 506 (3019)
– tosylamides from amides and *N*-methyl-*N*-tosylpyrrolidinium perchlorate 368 (2892)

Reactions

– *N*-(chloro-methylthiomethylene)-sulfonamides + 2-aminobenzamide 325 (2879)
– *N*-(3-hydroxyphenyl)-arenesulfonamides + potassium hydroxide + heat 175 (2715)

- *N,N*-Dihalosulfonamides

Reactions

– *N,N*-dibromotosylamide + bicyclo[3.3.1]nona-2,6-diene 699 (3217)
– *N,N*-dibromotosylamide + *cis,cis*-1,5-cyclooctadiene 699 (3217)
– *N,N*-dibromotosylamide + 9-oxabicyclo[3.3.1]nona-2,6-diene 699 (3217)
– *N,N*-dibromotosylamide + 9-tosyl-9-azabicyclo[3.3.1]-nona-2,6-diene 699 (3217)

- *N*-Halosulfonamides

Reactions

– *N*-bromo-*N*-methylalkanesulfonamides + 1-alkenes + irradiation 668

- Miscellaneous Types

Synthesis

– methyl 6-aminosulfonyl-6-deoxy-α-D-glucopyranosides from methyl 6-chlorosulfonyl-2,3,4-tri-*O*-acetyl-6-deoxy-α-D-glucopyranoside and amines 222

● Sulfonic Acid Azides

Reactions

– arenesulfonyl azides + *N,N*-disubstituted aminoacetylenes 553 (3051)

● Sulfonic Acid Esters

- General

Synthesis

– 2-chloroalkyl sulfonates from sulfonyl chlorides and oxiranes (+ quaternary aminium compounds) 450

- Alkanesulfonic Acid Esters

Synthesis

– aryl nonafluorobutanesulfonates from nonafluorobutanesulfonyl fluoride and sodium aryloxides 293
– 1-nonafluorobutylsulfonyl-oxycycloalkenes from cycloalkanones, sodium hydride, and nonafluorobutanesulfonyl fluoride 293
– phenyl bis[methylsulfonyl]-methanesulfonate 211
– phenyl methylsulfonylmethanesulfonates from methylsulfonylsulfene and phenols 211

Reactions

– 4-nitrophenyl arylmethanesulfonates + 1-dialkylaminopropynes 534
– 4-nitrophenyl phenylmethanesulfonate + 1-dimethylamino-2-methylpropene + base 534

– phenyl methylsulfonylmethanesulfonate + methylsulfonyl chloride + base 211

- Arenesulfonic Acid Esters

Synthesis

– 1,2-ditosyloxyethane 450

● Sulfonic Acid Halides

- General

Synthesis

– sulfonyl chlorides from chloromethyl sulfides and chlorine/water 691 (3183)

– sulfonyl fluorides from sulfonyl chlorides and fluoride-ion loaded anion-exchange resin 811 (3285)

- Alkanesulfonyl Halides

Synthesis

– 1-chlorocarbonylalkanesulfonyl chlorides from 2*H*-alkanoic acids and phosphoryl chloride/sulfur trioxide 557 (2066)

– 1-chloro-1-chlorocarbonylalkanesulfonyl chlorides from 1-chlorocarbonylalkanesulfonyl chlorides and phosphorus(V) chloride 632 (3138)

- Arenesulfonyl Halides

Reactions

– – desulfonylation in the presence or noble-metal catalysts 55 (2606)

– benzenesulfonyl chlorides + butadiene + copper(II) chloride 233 (2802)

– benzenesulfonyl chlorides + ethylene + copper(II) chloride 233 (2802)

– 1,3-bis[chlorosulfonyl]-benzene + phosphorus + iodine + acetic acid 436 (2964)

- Miscellaneous Types

Synthesis

– methyl 2,3,4-tri-*O*-acetyl-6-deoxy-α-D-glucopyranoside-6-sulfonyl chloride 222

● Sulfonic Acids

- General

Synthesis

– – from sulfonyl chorides and aqueous base in the presence of quaternary aminium compounds 449

- Alkanesulfonic Acids

Synthesis

– 2-(bis[3-hydroxy-6-hydroxymethyl-4-oxo-2-pyranylmethyl]-amino)-ethanesulfonic acid 729

– bis[methylsulfonyl]-methanesulfonic acid 211

– methylsulfonylmethanesulfonic acid, silver salt 211

– sodium aminomethanesulfonates from sodium hydrogen sulfite, formaldehyde, and primary amines 742

● Sulfonium Salts

Synthesis

– *N*-acetylaminodialkylsulfonium bromides from dialkyl sulfides and *N*-bromoacetamide 322 (2865)

– aminosulfonium 2,4,6-trimethylbenzenesulfonates from thioethers and *O*-mesitylsulfonylhydroxylamine 692 (3186)

– bis[chlorodialkylaminomethylenamino]-chlorosulfonium chlorides from dialkylcyanamides and sulfur dichloride or thionyl chloride 557 (3067)

– dimethyl-(succinimido)-sulfonium halides from *N*-halosuccinimides and dimethyl sulfide 625 (3106)

– ethylmethyl-(2-oxocycloalkyl)-sulfonium salts from 2-ethylthiocycloalkanones and dimethyl sulfate or methyl tosylate 631 (3135)

Reactions

– *N*-acetylaminodialkylsulfonium bromides + triethylamine 322 (2865)

– 1,2-alkadienyldimethylsulfonium bromides + *CH*-acidic alkyl ketones 815 (3302)

– 1,4-bis[dialkylsulfonio]-2-butene bromides + sodium alkoxide 557 (3064)

– 2-ethylmethylsulfonio-3-oxocycloalkene methylsulfates + β-dicarbonyl compounds + base 560 (3080)

● Sulfoxides

- General

Synthesis

– iodomethyl sulfoxides from sulfinyl chlorides, diazomethane, and alkali metal iodides 811 (3288)

Reactions

– – with *O,O*-dialkyl dithiophosphates 174 (2712)

– – with dichloroborane 42

– – with dithioacetic acid 174 (2713)

– – with ethanol + *N*-halosuccinimides 691 (3185)

– – with *O*-mesitylsulfonylhydroxylamines 692 (3186)

– – with tin(II) chloride/hydrochloric acid 206

– – with titanium(III) chloride 632 (3137)

– chloromethyl sulfoxides + chlorine 691 (3183)

- 1-Alkenyl Sulfoxides

Synthesis

– 1-alkenyl alkyl sulfoxides from *S*-alkyl alkanesulfinothioates and 1-alkynes 233 (2803)

– bis[1-alkenyl] sulfoxides from *S*-alkyl alkanesulfinothioates and 1-alkynes 233 (2803)

– methyl 1-methylthio-2-phenylethenyl sulfoxides from methyl methylthiomethyl sulfoxide and benzaldehydes 119 (2696

- Alkyl Aryl Sulfoxides

Synthesis

– methyl phenyl sulfoxide 352

Reactions

– – with iodobenzene dichloride 371 (2909)

– alkyl 2-carboxyphenyl sulfoxides + acetic anhydride 507 (3024)

– optically active alkyl aryl sulfoxides + alkyllithium 485

- Dialkyl Sulfoxides

Synthesis

– alkyl 2-ethoxycarbonylethyl sulfoxides from *S*-alkanesulfinothioates and ethyl acrylate 233 (2803)

– optically active dialkyl sulfoxides from optically active alkyl aryl sulfoxides and alkyllithium 485

Reactions

– dimethyl sulfoxide + *N*-halosuccinimides + alcohols 553 (3050)

– dimethyl sulfoxide + phosphine sulfides + acid 307

– dimethyl sulfoxide + triphenylarsine sulfide + acid 307

– ethyl 3-alkylsulfinylpropanoates from *S*-alkyl alkanesulfinothioates and ethyl acrylate 233 (2803)

– methyl methylthiomethyl sulfoxide + benzaldehydes 119 (2696)

- Diaryl Sulfoxides

Synthesis

– – from diaryl sulfides and cerium(IV) ammonium nitrate 352

- 1-Haloalkyl Sulfoxides

Synthesis

– 1-chloroalkyl phenyl sulfoxides from alkyl phenyl sulfoxides and iodobenzene dichloride 371 (2909)

- Miscellaneous Types

Synthesis

– *O,O*-dialkylphosphonomethyl sulfoxides from the corresponding sulfides and sodium periodate 669

– nucleotide 2-phenylsulfinylethyl esters from the 2-phenylthioethyl esters and sodium periodate 239 (2829)

● Sulfoximines

Synthesis

– – from sulfoxides and *O*-mesitylsulfonylhydroxylamines 692 (3186)

● Sulfoxonium Salts

Synthesis

– aminosulfoxonium trimethylbenzenesulfonates from sulfoxides and *O*-mesitylsulfonylhydroxylamine 692 (3186)

● Sulfurane *S*-Oxides

Synthesis

– dialkoxycarbonylmethylenesulfurane *S*-oxides from sulfoxides and dialkyl diazomalonates 144

Reactions

– dimethylmethylenesulfurane *S*-oxide + teriary boranes 648

● Sulfuranes

Synthesis

– α-alkylthiophenacyclidenedimethylsulfuranes from ω-alkylthio-ω-bromoacetophenones and dimethyl sulfide 501 (3002)

– α-arylthiophenacylidenedimethylsulfuranes from ω-arylthio-ω-bromoacetophenones and dimethyl sulfide 501 (3002)

– cyclopentadieneylidenedialkylsulfuranes from diazocyclopentadiene and dialkyl sulfides 811 (3284)

– dialkylidenesulfuranes *in situ* from 2,5-dihydro-1,3,4-thiadiazoles, thermally 817 (3310)

– dimethyl-(4-oxo-2-cycloalkenylidene)-sulfuranes from dimethyl-(2-oxocycloalkylidene)-sulfuranes and activated alkynes 501 (3000)

Reactions

– *S*-(dimethoxycarbonylmethylene)-sulfuranes + dithioacetic acid 174 (2713)

– dimethylmethylenesulfurane + alkyl 3-oxo-1-alkenyl sulfides 814 (3301)

– dimethylmethylenesulfurane + tertiary boranes 648

– dimethyl-(2-oxocycloalkylidene)-sulfuranes + activated alkynes 501 (3000)

– dimethyl-(trimethylsilyl-methylene)-sulfurane + diborane 648

● **Sultams (Cyclic Sulfonamides)**

Synthesis

– *N*-methylpropanesultams from *N*-(2-bromoalkyl)-*N*-methyl-alkanesulfonamides and butyl-lithium 668

● **Sydnones**

Synthesis

– – from *N*-nitroso-α-aminocarboxylic acids and acetic anhydride 471

● **Telluranes**

Reactions

– dichlorodiphenyltelluranes + Raney nickel/2-methoxyethyl ether 174 (2714)

● **Tellurophene**

Synthesis

- of the Ring Skeleton

– – from bis[trimethylsilyl]-butadiyne and sodium telluride 235 (1810)

● **Terpenes**

- Acylic Monoterpenes

Synthesis

– geranyl acetate 175 (2717)

- Cyclic Monoterpenes

Synthesis

– *trans*-chrysanthemic acid 809 (3275)

– β-pinene 367 (2888)

Reactions

– camphene + lead(IV) acetate 570

– olefinic monoterpenes + lead(IV) acetate 570

– β-pinene + iodine azide + acetonitrile 356

– α-pinene + iodine azide + nitriles 356

- Diterpenes

Synthesis

– ethylene-bis[abietic acids] from abietic acid, ethylene, palladium(II) acetate, and silver acetate 532

Reactions

– abietic acid + ethylene + palladium(II) acetate + silver acetate/acetic acid 532

- Sesquiterpenes

Synthesis

– (-)-frullanolide 242 (2840)

- Tetraterpenes

Configuration

– neoxanthin and related allenic tetraterpenes 27, 33

Synthesis

– β-carotene 461, 464

– lycopene 461

- Triterpenes

Synthesis

– 11α-acetoxyolean-12-ene 573

– cyclic methylenetriterpenes from cyclic *gem*-*N*-benzoyl-aminomethyltriterpenes and thionyl chloride 114 (2674)

– 2,3-epiminosqualene 622

– methyl-substituted cyclic olefinic triterpenes from *gem*-*N*-benzoylaminomethyl-triterpenes and phosphorus(V) oxide 114 (2674)

Reactions

– squalene + iodine azide 622

● **2,3,5,6-Tetraazabicyclo[5.2.0]-nonane**

- 2,3,5,6-Tetraazabicyclo[5.2.0]-non-1(7)-enes

Synthesis

- of the Ring Skeleton

– 2,6-dimethyl-8,9-dioxo der. 355

- 2,3,5,6-Tetraazabicyclo[5.2.0]-nona-1(7),3-dienes

Synthesis

- of the Ring Skeleton

– 2,6-dimethyl-8,9-dioxo der. from 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene and triethyl orthocarboxylates 355

● **2,4,6,8-Tetraazabicyclo[3.3.1]-nonane**

Synthesis

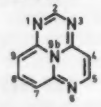
- of the Ring Skeleton

– 3,7-dioxo der. from 1,3-dicarbonyl compounds and ureas 257

– 3,7-dithiono der. from 1,3-dicarbonyl compounds and thioureas 258

– 3,7-dioxo der. from semiacetal chlorides, dimethylformamide, carbonyl chloride, and urea 258

● **1,3,6,9b-Tetraazaphenalene**

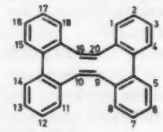


Synthesis

- of the Ring Skeleton

– – from 2-acylamino-6-(3-nitrolopropenylamino)-pyridines 324 (2873)

● **Tetrabenzo[*acgi*]dodecene**



- 9,10,19,20-Tetrahydrotetrabenzo-[*acgi*]dodecenes

Synthesis

- of the Ring Skeleton

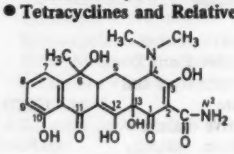
– – from 2,2'-bis[triphenyl-phosphoranylidenemethyl]-biphenyl and 2,2'-bis[bromo-methyl]-biphenyl 92

● **Tetracarboxylic Acid Esters**

Synthesis

– tetraethyl butadiene-1,2,3,4-tetracarboxylate 113 (2669)

● **Tetracyclines and Relatives**



Tetracycline

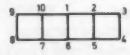
Synthesis

– N^2-dialkylaminomethyl der. from tetracyclines, formaldehyde, and dialkylamines 737

Reactions

– – *N*-aminomethylation of the carboxamide group by Mannich reaction 737

● **Tetracyclo[4.4.0.0^{2,5}.0^{7,10}]decane**



- Tetracyclo[4.4.0.0^{2,5}.0^{7,10}]deca-3,8-dienes

Synthesis

- of the Ring Skeleton

– – from alkynes, cyclobutadiene-tricarbonyliron, and cerium(IV) ammonium nitrate 667

● **Tetranitriles**

- Tetracyanoethylene

Reactions

– – with sodium azide 81

● **Tetrazenes**

Synthesis

– 1,1'-azo-bis[3-methyl-4-phenylimidazolium] dibromides 505 (3014)

– 1-(benzotriazol-1-yl)-4-tosyltetrazene, lithio der. 181 (2756)

● **1,2,4,5-Tetrazine**

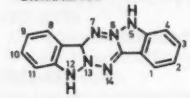
- Hexahydro-1,2,4,5-tetrazines

Synthesis

- of the Ring Skeleton

– 1,2,4,5-tetraphenyl der. 471

● **[1,2,4,5]Tetrazino[2,3-*b*:5,6-*b*']-diindazole**

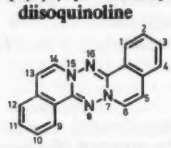


Synthesis

- of the Ring Skeleton

– – from 4-azido-1,2,3-benzo-triazine by irradiation 136

● **[1,2,4,5]Tetrazino[6,1-*a*;3,4-*a*']-diisoquinoline**



- 5,6,7,8,8a,13,14,15,16,16a-Deca-hydro[1,2,4,5]tetrazino[6,1-*a*;3,4-*a*]-diisoquinolines

Synthesis

- of the Ring Skeleton

– – from 2-(2-chloroethyl)-benz-aldehyde and hydrazine 471

● **1,3,5,7-Tetrazocine**

- Octahydro-1,3,5,7-tetrazocines

Synthesis

- of the Ring Skeleton

– 2,6-dioxo-1,3,5,7-tetraalkyl der. from *N*,*N*'-dialkyl-*N*-methoxymethylureas and acid 261

– 1,6-dioxo-1,3,5,7-tetraalkyl der. from 3,5-dialkyl-4-oxotetra-hydro-1,3,5-oxadiazines and *N*,*N*'-dialkylureas 247

– 2,6-dioxo-1,3,5,7-tetraalkyl der. from *N*,*N*'-dialkylureas and formaldehyde 261

Reactions

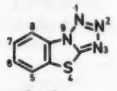
- Transformation of the Ring Skeleton

– 2,6-dioxo-1,3,5,7-tetramethyl der. + hydrochloric acid 261

● **Tetrazole**

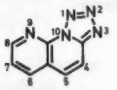
Synthesis
- of the Ring Skeleton
– – from carboximidoyl chlorides and sodium azide 83
– – from inorganic azides and nitriles 80
– – from nitrilium tetrafluoroborates and azide ion 235 (2811)
– 5-alkylthiotetrazoles from alkyl thiocyanates and sodium azide 81
– 5-arylthiotetrazoles from aryl thiocyanates and sodium azide 81
– 1-[7-(10-azido-*p*-menth-1-enyl)]-5-methyltetrazole 356
– 5-ethoxycarbonylmethyltetrazole 81
– 5-substituted 1-[7-(6-azido-*p*-menth-1-enyl)]-tetrazoles from α-pinene,iodine azide, and nitriles 356
– trifluoromethyltetrazole 81

● **Tetrazolo[5,1-*b*][1,3]benzothiazole**



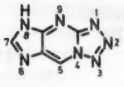
Synthesis
- of the Ring Skeleton
– – from 2-chloro-1,3-benzothiazole and ammonium azide 84

● **Tetrazolo[1,5-*a*][1,8]naphthyridine**



Reactions
- Retention of the Ring Skeleton
– 8-azido der. + nucleophiles 129

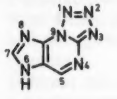
● **Tetrazolo[1,5-*a*]purine**



8*H*–

Synthesis
- of the Ring Skeleton
– – from 2-azidopurines by isomerization 129

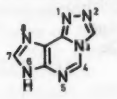
● **Tetrazolo[5,1-*b*]purine**



6*H*–

Synthesis
- of the Ring Skeleton
– – from 2-azidopurines by isomerization 129

● **Tetrazolo[5,1-*i*]purine**



6*H*–

Synthesis
- of the Ring Skeleton
– – from 6-azidopurines by isomerization 128
Reactions
- Ring-Cleavage Reactions
– – azido-tetrazolo isomerization 128

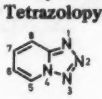
● **Tetrazolo[1,5-*a*]pyrazine**

Synthesis
- of the Ring Skeleton
– – from azidopyrazine by isomerization 128
Reactions
- Transformation of the Ring Skeleton
– – gas-phase pyrolysis 135

● **Tetrazolo[1,5-*b*]pyridazine**

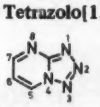
Synthesis
- from Like Ring Skeletons
– 6-azido-7(8)-methyl der. 132
– 6-(2-methoxycarbonyl-1-propenylamino) der. 134
- of the Ring Skeleton
– – from 3-azidopyridazine 1-oxides by deoxygenation 132
– – from 3-azidopyridazines by isomerization 126
– 6-amino-8-methyl der. 134
Reactions
- Ring-Cleavage Reactions
– – azido-tetrazolo isomerization 126
– – gas-phase pyrolysis 135
- Transformation of the Ring Skeleton
– – by irradiation 370 (2905)

● **Tetrazolopyridine**



Synthesis
- of the Ring Skeleton
– – from 2-azidopyridines by isomerization 126
– – from 2-bromopyridine and ammonium azide 84
Reactions
- Ring-Cleavage Reactions
– – azido-tetrazolo isomerization 126
– – with base 132
- Transformation of the Ring Skeleton
– – gas-phase pyrolysis 135
– – thermolysis in the presence of alkynes 135
– – thermolysis in the presence of benzonitrile 135
– – with alkynes 133

● **Tetrazolo[1,5-*a*]pyrimidine**



- Tetrazolo[1,5-*a*]pyrimidines
Synthesis
- of the Ring Skeleton
– – from 2-azidopyrimidines by isomerization 126
Reactions
- Ring-Cleavage Reactions
– – azido-tetrazolo isomerization 126
– 5,7-dimethyl der. + aqueous base 131

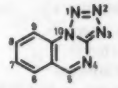
- 4,5-Dihydrotetrazolo[1,5-*a*]pyrimidines
Synthesis
- of the Ring Skeleton
– 4,7-dimethyl-5-oxo der. 127

● **Tetrazolo[1,5-*c*]pyrimidine**

- Tetrazolo[1,5-*c*]pyrimidines
Synthesis
- of the Ring Skeleton
– – from 4-azidopyrimidine by isomerization 127
Reactions
- Retention of the Ring Skeleton
– – hydration 127
- Transformation of the Ring Skeleton
– – gas-phase pyrolysis 135

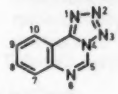
- 5,6-Dihydrotetrazolo[1,5-*c*]pyrimidines
Synthesis
- from Like Ring Skeletons
– 5-hydroxy der. 127

● **Tetrazolo[1,5-*a*]quinazoline**



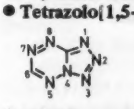
Synthesis
- of the Ring Skeleton
– – from 2-azidoquinazoline by isomerization 129

● **Tetrazolo[1,5-*c*]quinazoline**



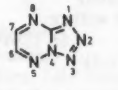
Synthesis
- of the Ring Skeleton
– – from 4-azidoquinazoline by isomerization 129

● **Tetrazolo[1,5-*b*][1,2,4,5]tetrazine**



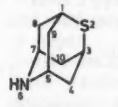
Synthesis
- of the Ring Skeleton
– – from 3-azido-1,2,4,5-tetrazine by isomerization 128

● **Tetrazolo[1,5-*b*][1,2,4]triazine**



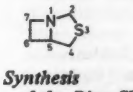
Synthesis
- of the Ring Skeleton
– 6,7-diphenyl der. 128

● **2-Thia-6-azaadamantanes**



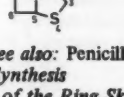
Synthesis
- of the Ring Skeleton
– 4,8-dichloro-6-formyl der. 375 (2928)
– 6-methyl der. 375 (2928)

● **3-Thia-1-azabicyclo[3.2.0]-heptane**



Synthesis
- of the Ring Skeleton
– 2,2-diethyl-7-oxo-6-phthalimido der. 335

● **4-Thia-1-azabicyclo[3.2.0]heptane**



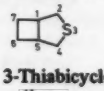
see also: Penicillins and Relatives
Synthesis
- of the Ring Skeleton
– – from 3-diazophenylacetyl-

tetrahydro-1,3-thiazoles by irradiation 343
– 5-acylamino-6,6-diphenyl-7-oxo der. from 2-acylamino-4,5-dihydro-1,3-thiazoles and diphenylketene 331
– 5-acylthio-6,6-diphenyl-7-oxo der. from 2-acylthio-4,5-dihydro-1,3-thiazoles and diphenylketene 331
– 2-aminocarbonyl-7-oxo-3,3,6-trimethyl der. from 2-(1-carboxyethyl)-5,5-dimethyl-2,5-dihydro-1,3-thiazoles and isocyanides 345
– (+)-6-bromo-3,3-dimethyl-2-methoxycarbonyl-7-oxo der. [(+)-methyl 6-bromopenicillinate] 346
– 3,3-dimethyl-2-methoxycarbonyl-7-oxo der. from 5,5-dimethyl-4-methoxycarbonyl-4,5-dihydro-1,3-thiazole and acyl chlorides 334
– 7-oxo-5-phenyl der. from 2-phenyl-4,5-dihydro-1,3-thiazole and alkanoyl chlorides 439 (2977)

● **3-Thia-7-azabicyclo[3.3.1]nonane**

Synthesis
- of the Ring Skeleton
– 1,5-dialkoxycarbonyl-9-oxo der. from 3,5-dialkoxycarbonyl-4-oxothiacyclohexanes, formaldehyde, and primary amines 725

● **3-Thiabicyclo[3.2.0]heptane**

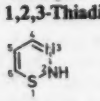


- 3-Thiabicyclo[3.2.0]hepta-1,4-dienes
Synthesis
- of the Ring Skeleton
– 6,7-dibromo-2,4-dihalo der. from 3,4-bis[dibromomethyl]-2,5-dihalothiophenes and sodium iodide 66 (2648)

● **2-Thia-4,7-diazabicyclo[3.2.0]-heptane**

Synthesis
- of the Ring Skeleton
– 3-*t*-butoxycarbonyl-2,2-dimethyl-6-oxo der. 329

● **1,2,3-Thiadiazine**



2*H*–

- 1,2,3-Thiadiazinium Salts
Synthesis
- of the Ring Skeleton
– cycloaliphatic-fused 1,2,3-thiadiazinium perchlorates from 1-hydrazonomethyl-2-thiocycloalkenes and perchloric acid 225

● **1,2,6-Thiadiazine**

2*H*–

- 2*H*-1,2,6-Thiadiazines
Synthesis
- of the Ring Skeleton
– 1,1-dioxides, from 1,3-dicarbonyl compounds and sulfamides 260

- 3,4-Dihydro-2*H*-1,2,6-thiadiazines
Synthesis
- of the Ring Skeleton
– 1,1-dioxides, from methyl ketones and sulfamide 285

- Tetrahydro-1,2,6-thiadiazines
Synthesis
- of the Ring Skeleton
– 3-aminosulfonylamino der. from 2-alkenals and sulfamide 290

● **1,3,4-Thiadiazine**

2*H*–

- 3,4-Dihydro-2*H*-1,3,4-thiadiazines
Synthesis
- of the Ring Skeleton
– 5-alkyl-3-aryl-2-imino, perchlorates, from 2-arylhydrazono-1-thiocyanato-alkanes 225

● **1,2,3-Thiadiazole**

Synthesis
- from Like Ring Skeletons
– 2-oxides, by oxidation with peroxoic acids 820 (3324)
– 1,1,2-trioxides, by oxidation with peroxoic acids 820 (3324)

● **1,2,4-Thiadiazole**

Synthesis
- of the Ring Skeleton
– 5-amino-3-(2-cyanophenyl) der. from 3-imino-1-aminoisoindoles, bromine/base, and potassium thiocyanate 696 (3203)

● **1,3,4-Thiadiazole**

- 1,3,4-Thiadiazoles
Reactions
- Ring-Cleavage Reactions
– – with sodium/alcohols 807 (3269)

- 2,5-Dihydro-1,3,4-thiadiazoles
Synthesis
- from Like Ring Skeletons
– – from tetrahydro-1,3,4-thiadiazoles and diethyl diazenedicarboxylate 817 (3310)

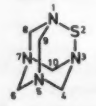
- Tetrahydro-1,3,4-thiadiazoles
Synthesis
- of the Ring Skeleton
– cycloalkane(spiro-2)tetrahydro-1,3,4-thiazole(5-spiro)cycloalkanes from cycloalkanones, hydrogen sulfide, and hydrazine 561 (3082)

● **Thiapyran**

2*H*–

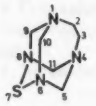
Synthesis
- of the Ring Skeleton
– 5-cyano der. from 2-thioacyl-3,4-pentadienenitriles, thermally 818 (3317)
– 2-thiono der. from cyclopentadiene-(triphenylphosphine)-cobalt, alkynes, and carbon disulfide 819 (3322)

● **2-Thia-1,3,5,7-tetraazaadamantanes**



Synthesis
- of the Ring Skeleton
– 2,2-dioxide 253

● **7-Thia-1,4,6,8-tetraazatricyclo[4.3.1.1^{4,8}]undecanes**



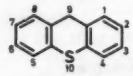
Synthesis
- of the Ring Skeleton
– 7,7-dioxide 253

● **1,2,4,6-Thiatriazine**

2*H*–

- Tetrahydro-1,2,4,6-thiatriazines
Synthesis
- of the Ring Skeleton
– 1,1-dioxides, from sulfamide, formaldehyde, and ammonia or alkylamines 253

● **Thiaxanthene**



- Thiaxanthenes
Reactions
- Retention of the Ring Skeleton
– thiaxanthene + cerium(IV) ammonium nitrate 352

- Thiaxanthones
Synthesis
- from Like Ring Skeletons
– thiaxanthone 352

● **1,3-Thiazine**

2*H*–

4*H*–

- 4*H*-1,3-Thiazines
Synthesis
- of the Ring Skeleton
– 6-alkylthio-5-aminocarbonyl-4-oxo der. from 3-alkylthio-2-cyano-3-mercaptopropenamides and carboxylic acids 819 (3321)
– 6-alkylthio-5-aminocarbonyl-4-thiono der. from 3-alkylthio-2-cyano-3-mercaptopropene-thioamides and carboxylic acids 819 (3321)

- 3,4-Dihydro-2*H*-1,3-thiazines
Synthesis
- of the Ring Skeleton
– 6-alkylthio-5-cyano-4-oxo der. from 3-alkylthio-2-cyano-3-mercaptopropenamides and aldehydes or ketones 697 (3209)

- 3,6-Dihydro-2*H*-thiazines
Synthesis
- of the Ring Skeleton

– 2-imino der. from 1-alkenyl ketones and thioureas 289

- 5,6-Dihydro-4*H*-1,3-thiazines

Synthesis

- of the Ring Skeleton

– 2-amino-4-hydroxy der. from thioureas and 1-alkenyl ketones 820 (3326)

– 4-hydroxy der. from thiocarboxamides and 2-alkenals or 1-alkenyl ketones 820 (3326)

Reactions

- Fusion of New Rings

– 2-aryl der. + 2*H*-acyl chlorides + triethylamine 335

– 2-phenyl der. + alkanoyl chlorides 439 (2977)

● 1,2-Thiazole

- 1,2-Thiazoles

Synthesis

- of the Ring Skeleton

– 4,5-diphenyl-3-hydroxy-1,2-thiazole 65 (2646)

- Tetrahydro-1,2-thiazoles

Synthesis

- of the Ring Skeleton

– 2-methyltetrahydro-1,2-thiazole 1,1-dioxides from *N*-(2-bromoalkyl)-*N*-methylalkanesulfonamides and butyllithium 668

● 1,3-Thiazole

- 1,3-Thiazoles

Synthesis

- from Like Ring Skeletons

– 2,2'-bi-1,3-thiazole 175 (2715)

- of the Ring Skeleton

– 5-aryl-4-tosyl der. from carboxymethyl arenedithiocarboxylates and tosylmethyl isocyanide 235 (2809)

Reactions

- Retention of the Ring Skeleton

– – aminomethylation by Mannich reaction 727

- 2,3-Dihydro-1,3-thiazoles

Synthesis

- of the Ring Skeleton

– 3-phenyl-2-selenono der. from 1-mercaptoalkyl ketones and phenyl isoselenocyanate 236 (2814)

– 2-thiono der. from 2-imino-1,3-dithiolanes and alkynes 439 (2978)

- 2,5-Dihydro-1,3-thiazoles

Reactions

- Fusion of New Rings

– 2-(1-carboxyethyl)-5,5-dimethyl der. + isocyanides 345

- 4,5-Dihydro-1,3-thiazoles

Reactions

- Fusion of New Rings

– – with acyl chlorides + triethylamine 334

– 2-phenyl der. + alkanoyl chlorides 439 (2977)

– 2-substituted der. + ketenes 331

- Ring-Cleavage Reactions

– 2-alkyl der. + mercury(II) chloride/water 553 (3048)

– 4-alkyl-5-oxo-2-phenyl der. + amino-acids or peptides + acetic anhydride 241 (2838)

– 3-substituted 2-(4-chlorophenyl)-5-oxo der. + formaldehyde + dialkylamines 728

- Tetrahydro-1,3-thiazoles

Synthesis

- of the Ring Skeleton

– 4-hydroxy-2-thiono der. from alkylaminium dithiocarbamates and α-bromo-aldehydes or -ketones 697 (3208)

– 4-hydroxy-2-thiono der. from ammonium dithiocarbamates and α-bromo-aldehydes or ketones 697 (3208)

– 4-hydroxy-2-thiono der. from ammonium dithiocarbamates and α-bromo-aldehydes or ketones 697 (3208)

– 2-(2-methoxycarbonylphenylimino)-5-methylene der. from methyl 2-isothiocyanatobenzoate and 3-amino-1-alkynes 426

Reactions

- Fusion of New Rings

– 3-diazophenylacetyl der., irradiation 343

– 4-ethoxycarbonyl-3-(oxophenylacetyl) der., irradiation 344

- Retention of the Ring Skeleton

– – aminomethylation by Mannich reaction 728

– 4-oxo-2-thiono der., *N*-aminomethylation by Mannich reaction 739, 741

● [1,3]Thiazolo[3,2-*b*]pyridazine

5*H*–

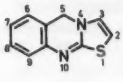
- [1,3]Thiazolo[3,2-*b*]pyridazinium Salts

Synthesis

- of the Ring Skeleton

– – from 6-(2-oxoalkylthio)-tetrazolo[1,5-*b*]pyridazines 133

● [1,3]Thiazolo[2,3-*b*]quinazoline



5*H*–

- 2,3-Dihydro-5*H*-[1,3]thiazolo-[2,3-*b*]quinazolines

Synthesis

- of the Ring Skeleton

– 2-methylene-5-oxo der. from methyl 2-isothiocyanatobenzoate and 3-amino-1-alkynes 426

● Thieno[2,3-*b*]pyrrole

6*H*–

Synthesis

- of the Ring Skeleton

– 5-aryl der. from 2-nitro-3-styrylthiophenes and triethyl phosphite 313

● Thieno[3,2-*b*]pyrrole

4*H*–

Synthesis

- of the Ring Skeleton

– 5-aryl der. from 3-nitro-2-styrylthiophenes and triethyl phosphite 313

● Thieno[2,3-*b*]thiophene

- 2,3-Dihydrothieno[2,3-*b*]thiophenes

Synthesis

- of the Ring Skeleton

– 5-amino-4-alkoxycarbonyl der. from alkyl tetrahydro-3-thienylidenecyanoacetates and sulfur 695 (3199)

● Thieno[3,2-*d*][1,2,3]triazine

- 6,7-Dihydrothieno[3,2-*d*][1,2,3]-triazines

Synthesis

- of the Ring Skeleton

– 2-alkylthio-7-oxo der. from 2-alkylthio-4-amino-5-amino-carbonylthiophenes and nitrous acid 505 (3017)

● Thieno[3,4-*d*][1,2,3]triazine

- 4,5-Dihydrothieno[3,4-*d*][1,2,3]-triazines

Synthesis

- of the Ring Skeleton

– 3-alkylthio-4-oxo der. from 2-alkylthio-4-amino-3-amino-carbonylthiophenes and nitrous acid 505 (3017)

● Thiete

- Thietes

Synthesis

- from Like Ring Skeletons

– – from 3-pyrrolidinothietanes and (1.) methyl iodide, (2.) base 322 (2867)

- of the Ring Skeleton

– – from 1-pyrrolidino-1-alkenes and methanesulfonyl chloride (4 steps) 322 (2867)

– 2-aryl-3-dialkylamino-4-methylthiete 1,1-dioxides from 4-nitrophenyl arylmethanesulfonates and 1-dialkylaminopropyne 534

- Thietanes

Synthesis

- of the Ring Skeleton

– 3-dialkylamino-2,2-dimethyl-4-phenylthietane 1,1-dioxides from 4-nitrophenyl phenylmethanesulfonate and 1-dialkylamino-2-methylpropenes 534

– 3,3-dialkyl-2,4-dioxothiethanes from 4,4-dialkyl-3,5-dioxo-1,2-dithiolanes and triphenylphosphine 559 (3074)

– 3-pyrrolidinothietane 1,1-dioxides from 1-pyrrolidino-1-alkenes and methanesulfonyl chlorides 322 (2867)

– 3-pyrrolidinothietanes from the 1,1-dioxides and lithium alanate 322 (2867)

Reactions

- Retention of the Ring Skeleton

– 3-(1-methylpyrrolidinio)-thietane iodides + potassium *t*-butoxide 322 (2867)
– 3-pyrrolidinothietane 1,1-dioxides + lithium alanate 322 (2867)

● **Thiirene**

- Thiiranes
Synthesis
- of the Ring Skeleton
– – from 2,5-dihydro-1,3,4-thiadiazoles, thermally 817 (3310)
– – from oxiranes and phosphine sulfides 183 (2752)

● **Thiocarbamic Acid Esters (Carbamothioic Acid Esters)**
- *O*-Esters
Synthesis
– *O*-(2-methoxycarbonylphenyl)-*N*-arylthiocarbamates from *O*-(2-methoxycarbonylphenyl) carbonochloridothioates and arylamines 325 (2878)
Reactions
– *O*-aryl thiocarbamates, thermal rearrangement 371 (2907)
– *O*-(2-methoxycarbonylphenyl) *N*-arylthiocarbamates + acid 325 (2878)
- *S*-Esters
Synthesis
– *S*-alkyl *N*-phenylcarbamothioates from *S*-alkyl-*N*-phenylisothiourea hydrobromides and isopentyl nitrite 690 (3180)
– *S*-aryl thiocarbamates from *O*-aryl thiocarbamates, thermally 371 (2907)
– *S*-(3,5-di-*t*-butyl-4-hydroxybenzyl) *N,N*-alkanediylcarbamothioates from *N,N*-alkanediyl-*N*-(3,5-di-*t*-butyl-4-hydroxybenzyl)-amines and carbonyl sulfide 556 (3060)

● **Thiocarbamic Acid Halides**
Reactions
– 2-cyanophenyl-thiocarbamoyl chlorides (bromides) + hydrogen halide 192

● **Thiocarboxylic Acid Amides**
- General
Reactions
– – *N*-aminomethylation by Mannich reaction 738
– – with formaldehyde 738
- Alkanethioamides
Synthesis
– dimethylthioformamide 149
- 2-Alkenethioamides
Reactions
– 2-acyl-3-amino-2-butenethioamides + phenacyl bromides 375 (2927)
– 3-alkylthio-2-cyano-3-mercaptopropenamides + carboxylic acids + polyphosphoric acid ethyl ester 819 (3321)
- Heterocyclic Thiocarboxamides
Synthesis
– 1-aminothiocarbonyl-1-cyano-3,4-dihydro-1*H*-2-benzothiapyrans from 1-cyano-3,4-dihydro-1*H*-2-benzothiapyrans and organic isothiocyanates 297
– 1-aminothiocarbonyl-1-cyano-isochromans from 1-cyano-isochromans and organic isothiocyanates 297
– 1-cyano-1-morpholinothiocarbonylisochroman 297
– 6-morpholinothiocarbonyl-2-oxo 1,2,3,4-tetrahydropyrimidines from the 6-methyl der. sulfur, and morpholine 276
– 6-morpholinothiocarbonyl-2-thiono-1,2,3,4-tetrahydropyrimidines from the 6-methyl der. sulfur, and morpholine 276

- Thioformamides
Synthesis
– – from formaldehyde, sulfur, and primary or secondary amines 552 (3047)

● **Thiocarboxylic Acid Esters**
- *O*-Esters, General
Synthesis
– – from carboxylic acid esters and phosphorus(V) sulfide 149
- *S*-Esters, General
Synthesis
– *S*-phenyl thiocarboxylates from carboxylic acids, diphenyl disulfide, and triphenylphosphine 62 (2635)
Reactions
– – with phosphorus(V) sulfide 149
- Alkanethioic Acid Esters
Synthesis
– *S*-butyl 3-hydroxyalkanethioates from ketones, butylthiodibutylborane, and ketene 631 (3134)
– *S*-phenyl 3-phenylthiobutanethioate 62 (2635)

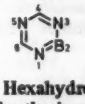
● **Thiocarboxylic Acids**
- Arenecarbothioic Acids
Reactions
– sodium arenecarbothioates + sodium hydroxylamine-*O*-sulfonate 556 (3063)

● **Thiocyanates**
- Alkyl Thiocyanates and Unsaturated Analogs
Synthesis
– – from alkyl halides and sodium thiocyanate 448
– 1-formyl-2-thiocyanatocycloalkenes from 2-chloro-1-formylcycloalkenes and potassium thiocyanate 225
– 3-oxo-3-phenyl-1-thiocyanatopropenes from diphenyl 3-oxo-3-phenylpropenyl phosphates and potassium thiocyanate 806 (3264)
Reactions
- Cyclization Reactions
– alkyl thiocyanatoacetates + aldehydes + base 373 (2916)
- Aryl Thiocyanates
Reactions
– – with dimethyl sulfoxide + sodium cyanide 811 (3287)
– 2-thiocyanatobenzoic acids + phosphorus(V) chloride 191
- Miscellaneous Types
Synthesis
– *N,N'*-dialkyl-*N*-thiocyanatoacetylthioureas from *N,N'*-dialkylthioureas and ethyl thiocyanatoacetate 690 (3181)
– *N,N'*-dialkyl-*N*-(α-thiocyanatocinnamoyl)-thioureas from *N,N'*-dialkyl-thioureas, ethyl thiocyanatoacetate, and benzaldehydes 690 (3181)

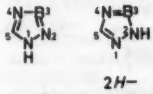
● **Thioethers**
- General
Synthesis
– – from organic disulfides, dimethyl sulfoxide, and sodium cyanide 435 (2963)
– – from sulfoxides and *O,O*-dialkyl dithiophosphates 174 (2712)
– – from sulfoxides and dichloroborane 42
– – from sulfoxides and dithioacetic acid 174 (2713)
– – from sulfoxides and tin(II) chloride/hydrochloric acid 206
– – from sulfoxides and titanium-(III) chloride 632 (3137)
– – from *N*-tosylsulfoximines and *O,O*-dialkyl dithiophosphates 174 (2712)
– – from *N*-tosylsulfilimines and dithioacetic acid 174 (2713)
– methyl sulfides from organic disulfides, dimethyl sulfoxide, and sodium cyanide 436 (2963)
Reactions
– – with *O*-mesitylsulfonylhydroxylamine 692 (3186)
– alkyl sulfides + lead(IV) acetate 576
– chloromethyl sulfides + chlorine + water 691 (3183)
- 1-Alkenyl Sulfides
Synthesis
– 1-alkenyl phenyl sulfides from ethylidenetriphenylphosphorane and (1.) *N*-methyl-*N*-phenylthioacetamide, (2.) aldehydes or ketones 63 (2637)
– 1-alkenyl phenyl sulfides from 1-phenylthioethylidenetriphenylphosphorane and aldehydes or ketones 63 (2637)
– alkyl 3-oxo-1-alkenyl sulfides from 1*H*,1*H*-alkyl ketones, ethyl formate, and alkylmercaptans 814 (3301)
– *trans*-1-alkylthiobutadienes from *trans*-1-dialkylsulfoniobutadiene bromides, thermally 557 (3064)
– 2-alkylthio-3-oxocycloalkenes from ethylmethyl-2-oxocycloalkylsulfonium methyl sulfates and *N*-alkylthiophthalimides 556 (3062)
– 2-arylthio-3-oxocycloalkenes from ethylmethyl-2-oxocycloalkylsulfonium methyl sulfates and *N*-arylthiophthalimides 556 (3062)
– bis[3-oxo-3-phenylpropenyl]-sulfides from diphenyl 3-oxo-3-phenylpropenyl phosphates and sodium sulfide 811 (3286)
- Alkyl Aryl Sulfides
Synthesis
– – from diaryl disulfides, alcohos, and cyanide ion 436 (2965)
– alkylaminomethyl aryl sulfides from arenethiols and 1,3,5-trialkylhexahydro-1,3,5-triazines 58 (2614)
– aryl 4-aminobenzyl sulfides from anilinomethyl aryl sulfides and acid 753
– methyl aryl sulfides from arenethiols, dimethyl sulfoxide, and sodium cyanide 811 (3287)
– methyl aryl sulfides from aryl thiocyanates, dimethyl sulfoxide, and sodium cyanide 811 (3287)
– 1-phenylthioalkyl ketones from *O*-trimethylsilylenols and benzenesulfenyl chloride 371 (2908)
Reactions
– *gem*-acyloxy-(phenylthiomethyl)-cycloalkanes + lithium/ammonia 56 (2610)
– *N*-alkyl-*N*-arylthiomethyl-

nitramines + phthalomonoperoxoic acid 303
– aminomethyl phenyl sulfides + organomagnesium halides 765
– diphenylmethyl phenyl sulfides + lithium alanate/copper(II) chloride 366 (2883)
– methyl phenyl sulfide + cerium(IV) ammonium nitrate 352
- Dialkyl Sulfides
Synthesis
– alkyl alkylaminomethyl sulfides from alkylmercaptans and 1,3,5-trialkylhexahydro-1,3,5-triazine 58 (2614)
Reactions
– – with *N*-bromoacetamide 322 (2865)
– – with diazocyclopentadiene + irradiation 811 (3284)
– *N*-alkyl-*N*-alkylthiomethyl-nitramines + phthalomonoperoxoic acid 303
– alkyl diphenylmethyl sulfides + lithium alanate/copper(II) chloride 366 (2883)
- Diaryl Sulfides
Synthesis
– 4,4'-dihydroxy-2,2',6,6'-tetraalkyldiphenyl suldides from 2,6-dialkylphenols, sulfur, and base 38
– perfluorodiphenyl sulfide 52
Reactions
– – with cerium(IV) ammonium nitrate 352
- Heterocyclic Sulfides (Het-S-Het, Het-S-R)
Synthesis
– bis[2-oxohexahydro-4-pyrimidyl] sulfides from 4-hydroxy-2-oxohexahydropyrimidines and hydrogen sulfide 263
– 3,3'-thiobis(5-amino-4-alkoxycarbonyl-2,3-dihydrothieno[2,3-*b*]thiophenes) 695 (3199)
Reactions
– – reductive cleavage with hydrazine 695 (3199)
– 2-alkylthio-4,5-dihydro-1,3-thiazoles + methyl iodide 228 (2782)
– 2,4-dialkyl-5-phenylthioimidazoles + Raney nickel 374 (2923)
● Thiohydroximic Acids and Derivatives
Reactions
– benzothiohydroximic acid + *N*-dichloromethylenesulfonamides 323 (2870)
● Thioketones
Synthesis
– – from ketones and *O,O*-diethyl phosphorodithioate 117 (2687)
– – from ketones and phosphorus(V) sulfide 149
Reactions
– – with ozone 617
– thiocamphor + benzylamines 535
● Thiophene

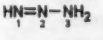
- Thiophenes
Synthesis
- from Like Ring Skeletons
– 3-hydroxy-4-methylthiophene 746
– 2-nitro-3-styrylthiophenes from 3-methyl-2-nitrothiophenes and benzaldehydes 313
– 3-nitro-2-styrylthiophenes from 2-methyl-3-nitrothiophenes and benzaldehydes 313
– 2-styryl- and 2,5-distyrylthiophenes from thiophene, styrene, and palladium(II) acetate 530
- of the Ring Skeleton
– 2-amino-3,5-diacylthiophenes from 2-acyl-3-amino-2-butenethioamides and phenacyl bromides 375 (2927)
– 4-cyano-2-methylthiophenes from 2-thioacyl-3,4-pentadienenitriles, thermally 818 (3317)
– 3,4-dialkoxycarbonylthiophenes from 2,5-dihydro-1,3,4-thiadiazoles and dialkyl acetylenedicarboxylates 817 (3310)
Reactions
- Fusion of New Rings
– 2-alkylthio-4-amino-3-aminocarbonylthiophenes + nitrous acid 505 (3017)
– 2-alkylthio-4-amino-5-aminocarbonylthiophenes + nitrous acid 505 (3017)
– 2-nitro-3-styrylthiophenes + triethyl phosphite 313
– 3-nitro-2-styrylthiophenes + triethyl phosphite 313
- Ring-Cleavage Reactions
– – desulfurization with sodium borohydride/nickel(II) chloride 317 (2843)
- 2,3-Dihydrothiophenes
Synthesis
- from Like Ring Skeletons
– 4-amino 1,1-dioxides from 3-aminocarbonyloxy-4-bromotetrahydrothiophene 1,1-dioxides and base 504 (3013)
- Tetrahydrothiophenes
Synthesis
- from Like Ring Skeletons
– 2,5-diaryl-4-hydroxy-3-oxo 1,1-dioxides from the 2,3-dihydro analogs and zinc/acetic acid 551 (3043)
Reactions
- Retention of the Ring Skeleton
– – aminomethylation by Mannich reaction 727
- Ring-Cleavage Reactions
– 2,5-diaryl-3-hydroxy-4-oxotetrahydrothiophene 1,1-dioxides + weak acid 551 (3043)
● Thiourea and Derivatives
- General
Synthesis
– cyclic thioureas by α-thioureidoalkylation reactions 243
- Hetero-Substituted Thioureas
Synthesis
– styrylsulfonyl-thioureas from 2-phenylethylenesulfonamides and alkyl isothiocyanates 820 (3325)
- Thiourea and Carbo-Substituted Thioureas
Synthesis
- from Other Thioureas
– dialkylaminomethyl-thioureas from thiourea, formaldehyde, and dialkylamines 738
– *N,N*-dialkyl-thioureas from *N'*-acyl-*N,N*-dialkyl-thioureas and aqueous acid 691 (3182)
– hydroxymethyl-thiourea 738
- Other Methods of Synthesis
– *N'*-acyl-*N,N*-dialkyl-thioureas from acyl isothiocyanates and dialkylamines 691 (3182)
– *N'*-alkoxycarbonyl-*N,N*-dialkyl-thioureas from alkoxycarbonyl isothiocyanates and dialkylamines 691 (3182)
– phenyl-thioureas from anilines and sodium thiocyanate 435 (2961)
Reactions
- Cyclization Reactions
– – with 2*H*-alkanals + acid 262
– – with 1-alkenyl ketones 281, 289
– – with bis[1-alkenyl] ketones 291
– – with cyclohexanone 281
– – with *vic*-dicarbonyl compounds 254
– – with 4,5-dihydroxy-2-oxo-imidazolidines 254
– – with formaldehyde + alkylamines 251
– *N*-(1-alkoxyalkyl)-thioureas + alkenes 286
– alkoxymethyl-thioureas + 1-alkynes + acid 286
– thiourea + aldehydes + ammonia or alkylamines 252
– thioureas + 2*H*-alkanals + alcohols + hydrogen chloride 262
– thiourea + 4,5-dialkoxy-2-oxo-imidazolidines + acid 251
– thiourea + dialkyl ketones 281
– thioura + 4,5-dihydroxy-2-oxo-imidazolidines + acid 251
– thiourea + 3-oxobutanal bis-[dimethyl acetal] 259
- without Cyclization
– acetyl-thiourea + 1-haloalkanes + ethanol 115 (2680)
– thiourea, aminomethylation by Mannich reaction 738
– thiourea + formaldehyde 738
- Miscellaneous Types
Synthesis
– *N,N'*-dialkyl-*N*-thiocyanato-acetyl-thioureas from *N,N'*-dialkyl-thioureas and ethyl thiocyanatoacetate 690 (3181)
– *N,N'*-dialkyl-*N*-(α-thiocyanato-cinnamoyl)-thioureas from *N,N'*-dialkylthioureas, ethyl thiocyanatoacetate, and benzaldehydes 690 (3181)
● Triarylmethane Dyes and Derivatives
Synthesis
– malachite green 353
Reactions
– leuco malachite green + cerium(IV) ammonium nitrate 353
● 1,3,5,2-Triazaborin



- Hexahydro-1,3,5,2-triazaborins
Synthesis
- of the Ring Skeleton
– 2,3-diphenyl-4-thiono der. from 2-phenyl-1,3,2-diazaborolidines and phenyl isothiocyanate 656
● 1,2,4,3-Triazaborole



2*H*–
- 3,4-Dihydro-2*H*-1,2,4,3-triazaboroles
Synthesis
- of the Ring Skeleton
– tetraphenyl der. 636
● Triazenes



Synthesis
– 1-alkyl-3-(2-ethoxycarbonylphenyl)-triazenes from 2-ethoxycarbonylbenzenediazonium salts and alkylamines 237 (2822)
Reactions

– 1-alkyl-3-(2-ethoxycarbonylphenyl)-triazenes, thermal cyclization 237 (2822)

● **1,3,5-Triazepine**

- Hexahydro-1,3,5-triazepines
Synthesis
- of the Ring Skeleton
– 1,5-dinitro der. from 1,2-bis[nitramino]-ethane, formaldehyde, and primary amines 736

● **1,2,3-Triazine**

Synthesis
- of the Ring Skeleton
– – from azidotriarylcyclopropenes, thermally 325 (2875)
– – from triarylcyclopropylium bromides and sodium azide 325 (2875)

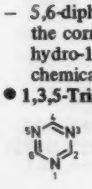
● **1,2,4-Triazine**

- 2,3-Dihydro-1,2,4-triazines
Reactions
- Retention of the Ring Skeleton
– 5,6-diphenyl-3-oxo der., electrochemical reduction 238 (2824)
– 5,6-diphenyl-3-thiono der., electrochemical reduction 238 (2824)
– 3-oxo der., *N*-aminomethylation by Mannich reaction 740

- 2,3,4,5-Tetrahydro-1,2,4-triazines
Synthesis
- from Like Ring Skeletons
– 5,6-diphenyl-3-oxo der. from the corresponding 2,3-dihydro-1,2,4-triazines by electrochemical reduction 238 (2824)
– 5,6-diphenyl-3-thiono der. from the corresponding 2,3-dihydro-1,2,4-triazines by electrochemical reduction 238 (2824)
- of the Ring Skeleton
– 6-nitro-2-phenyl der. from nitroformaldehyde phenylhydrazones, formaldehyde, and primary amines 733
Reactions
- Retention of the Ring Skeleton
– 5,6-diphenyl-3-oxo der., electrochemical reduction 238 (2824)
– 5,6-diphenyl-3-thiono der., electrochemical Reduction 238 (2824)
- Transformation of the Ring Skeleton
– 5,6-diphenyl-3-oxo der., electrochemical reduction 238 (2824)
– 5,6-diphenyl-3-thiono der., electrochemical reduction 238 (2824)

- Hexahydro-1,2,4-triazines
Synthesis
- from Like Ring Skeletons
– 5,6-diphenyl-3-oxo der. from the corresponding 2,3,4,5-tetrahydro-1,2,4-triazines by electrochemical reduction 238 (2824)
– 5,6-diphenyl-3-thiono der. from the corresponding 2,3,4,5-tetrahydro-1,2,4-triazines by electrochemical reduction 238 (2824)

● **1,3,5-Triazine**



- 1,3,5-Triazines
Synthesis
- from Like Ring Skeletons
– – trifluoro-1,3,5-triazine 487
- of the Ring Skeleton
– 2-alkoxy-4-alkyl(aryl)-6-(2-hydroxyphenyl) der. from 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine, amidines, and sodium alkoxides 562 (3088)
– 2-alkoxy-4-dialkylamino-6-(2-hydroxyphenyl) der. from 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine, *N,N*-dialkylguanidines, and sodium alkoxides 562 (3088)
– 2-amino-4-anilino-6-(2-oxopropyl) der. from N^1-arylbiguanides and diketene 536
– 2-aryl-4,6-bis[dialkylamino] der. from 2-aryl-4,6-bis[dialkylamino]-1,3,5-oxadiazinium chlorides and ammonia 202
– 2-aryl-4-dimethylamino-6-hydroxy der. from 2-aryl-4,6-bis[dimethylamino]-1,3,5-oxadiazinium chlorides and ammonia 202
– 4-chloro-2,6-diaryl der. from *N*-(α-chlorobenzylidene)-carbamoyl chlorides and arenecarbonitriles 200
– 4-chloro-2,6-diphenyl der. from benzonitriles, hydrogen chloride, and carbonyl chloride 199
– 2,4-dialkoxy-4-(2-hydroxyphenyl) der. from 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine, *O*-alkylisoureas, and sodium alkoxides 562 (3088)
– 2,4-diphenyl der. from 4-oxo-2-phenyl-4*H*-1,3-benzoxazines and amidines 506 (3018)
– 2,4-disubstituted 6-(2-hydroxyphenyl) der. from phenyl 2-hydroxybenzoates and amidines 563 (3090)

- Hexahydro-1,3,5-triazines
Synthesis
- from Like Ring Skeletons
– 1-phenyl-2,4,6-trioxo der. from 2,4-diimino-6-oxo(thiono)-1-phenyl der. and hydrochloric acid 666
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– 1,3,5-trimethyl der. + phosphorus-(V) chloride 433 (2950)

● **1,3,5-Triazocine**

- Octahydro-1,3,5-triazocines
Synthesis
- of the Ring Skeleton
– 1,ω-bis[1,5-dinitrooctahydro-1,3,5-triazocin-3-yl]-alkanes from 1,3-bis[nitramino]-propane, 1,ω-diaminoalkanes, and formaldehyde 736

● **1,2,3-Triazole**

2*H*–

- 1,2,3-Triazoles
Synthesis
- of the Ring Skeleton
– 1-(1-alkenyl) der. from 1-azidoalkenes and 2-oxoalkylidenetriphenylphosphoranes 817 (3311)
– 1-alkyl-4-aryl der. from arenecarbonitriles and alkyl(lithiomethyl)-nitrosamines 633 (3141)
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- of the Ring Skeleton
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● **1,2,4-Triazole**

4*H*–

- 1,2,4-Triazoles
Synthesis
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– 1-chloro der. from 1*H* der. and chlorine 695 (3198)
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Synthesis
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– 4-amino-3-phenyl der. from 4-chloroquinazolines and hydrazine hydrate 374 (2921)

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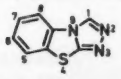
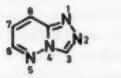
– 5-hydroxy-1-phenacyl der. from 1-phenacyl-1,2,4-triazolium bromides and aqueous base 414

● 1,2,4-Triazolo[3,4-*b*]benzotriazole



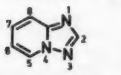
Synthesis
- of the Ring Skeleton
– 3-aryl der. from 2-benzylidenehydrazino-1,3-benzothiazoles and bromine 66 (2650)

● [1,2,4]Triazolo[4,3-*b*]pyridazine



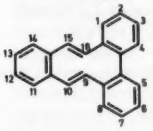
Synthesis
- of the Ring Skeleton
– 6-azido der. from tetrazolo-[1,5-*b*]pyridazines 133

● [1,2,4]Triazolo[2,3-a]pyridine



Synthesis
- of the Ring Skeleton
– 2-phenyl der. 135

● Tribenzo[*acg*]cyclodecene



- Tribenzo[*acg*]cyclodecenes
Synthesis
- of the Ring Skeleton
– – from *o*-phthaldialdehyde and 2,2'-bis[triphenylphosphoranylidenemethyl]-biphenyl 92
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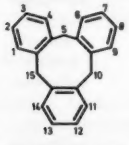
- of the Ring Skeleton
– – from 2,2'-bis[triphenylphosphoranylidenemethyl]-biphenyl and 1,2-bis[bromomethyl]-benzene 92

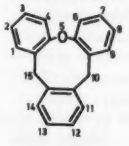
● Tribenzo[*a,d,g*]cyclononene



10,15-Dihydro-5*H*-

Synthesis
- of the Ring Skeleton
– – from 2,2'-bis[hydroxymethyl]-diphenylmethane and benzene 238 (2826)

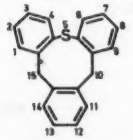
● Tribenzo[*b,e,h*]oxonin



10,15-Dihydro-

Synthesis
- of the Ring Skeleton
– – from bis[2-hydroxymethylphenyl]ether and benzene 238 (2826)

● Tribenzo[*b,e,h*]thionin



10,15-Dihydro-

Synthesis
- of the Ring Skeleton
– – from bis[2-hydroxymethylphenyl]sulfide and benzene 238 (2826)

● Tricarboxylic Acid Esters
- 1,1,n-Tricarboxylic Acid Esters
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– trimethyl acetylmethanetricarboxylate 61 (2629)
- 1,3,n-Tricarboxylic Acid Esters
Synthesis
– diethyl 3-ethoxycarbonyl-3-methyl-4-oxooctanedioate 213

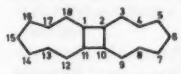
● Tricyclo[3.3.1.1^{2,6}]decane
see: Twistane

● Tricyclo[5.2.1.0^{2,6}]decane
see: 4,7-Methanoindene, Octahydro-

● Tricyclo[2.2.1.0^{2,6}]heptanes

Synthesis
- of the Ring Skeleton
– 5-methoxy-3-methoxycarbonyl der. 521

● Tricyclo[9.7.0.0^{3,10}]octadecane



- Tricyclo[9.7.0.0^{7,10}]octadeca-2,18-dienes
Synthesis
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– – from 1,2-cyclononadiene by dimerization 36

● 1,2,4-Trioxepin

5*H*-

- 1,2,4-Trioxepanes
Synthesis
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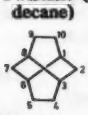
● Twistane (Tricyclo[3.3.1.1^{2,6}]decane)



- Tricyclo[3.3.1.1.^{2,6}]dec-3-enes
Synthesis
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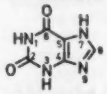
● **Xanthines**



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– 7-aryl-1,3-dimethylxanthines from 6-alkylamino-1,3-dimethyluracils and nitrosobenzenes 817(3313)
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Oxygen/Sulfur Exchange
Reductive Cyclization, Methods
Reductive Cyclization, Types
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Ring-Enlargement Reactions
Ring Transformation of Bi- and Polycyclic Compounds

The brutto formulas and atom sequences given under these headings refer only to the atoms forming the new rings. Whether or not these atoms themselves form part of a ring system is not recorded. In the atom sequences given, atoms common to both rings of bicyclic systems are underlined.

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- *C*-Acyloxylation
Replacement of Hydrogen
– – acyloxylations involving metal salts 567
– 17-acetoxy-4-methyl-1,3,5(10)-estratrienes + cerium(IV) ammonium nitrate 601
– α*H*-aldehydes + lead(IV) acetate 577
– 2*H*-alkanoic acids + thallium(III) acetate 593
– alkenes + acetic acid + oxygen + palladium(II) salts 595
– alkenes containing allylic hydrogen + lead(IV) acetate 570

– αH-carbonyl compounds + lead(IV) acetate + boron trifluoride 583
– carboxylic acid der. + lead(IV) acetate 585
– chloroalkanes + lead (IV) acetate 576
– hydrocarbons + manganese(III) acetate 598
– αH-ketones + mercury(II) acetate 591
– αH-ketones + thallium(III) acetate 592
– keto-steroids + lead(IV) acetate 583
– methylarenes + chromyl acetate 598
– methylarenes + cobalt(III) acetate 598
– methylbenzenes + acetic acid + oxygen + palladium(II) salts 595
– methylbenzenes + acetic acid + palladium(II) salts 595
– non-terminal alkynes + lead(IV) acetate 573
– toluene + acetic anhydride + oxygen + silver acetate 602
– unsaturated hydrocarbons + halosilver dibenzoates 600

- *P*-Acyloxylation
Additive Acyloxylation
– triphenylphosphine + carbon tetrachloride + carboxylic acids 60 (2623)

● 1-Alkenylation
- *B*-(1-Alkenylation)
Replacement of Hydrogen
– 1,3,2-benzodioxaborole + alkynes 437 (2970)
- *C*-(1-Alkenylation)
Reductive 1-Alkenylation of Carbon Multiple Bonds
– alkyl 2,4-pentadienoates + vinylcopper 807 (3267)
– 2-methoxyacrolein + 1-alkenyllithium 104
– methyl 2-alkynoates + 1-alkenylcopper 119 (2699)
– methyl 2-alkynoates + lithium bis[1-alkenyl]-cuprates 119 (2699)
Replacement of Hydrogen
– aldehyde phenylhydrazones (sodium salts) + 1-dimethylamino-2-nitro-1-alkenes 613
– alkyl acetoacetates + (1.) sodium hydride, (2.) vinyl halide 683 (3152)
– ferrocene + 1-alkenes + palladium(II) acetate 530
– furan + styrene + palladium(II) acetate 530
– 1-methylpyrrole + styrene + palladium(II) acetate 530
– 2-phenylalkanenitriles + 1-alkynes + base 451
– selenophene + styrene + palladium (II) acetate 530
– thiophene + styrene + palladium (II) acetate 530
- *N*-(1-Alkenylation)
Replacement of Hydrogen
– *N*-acyl-*N*,*N*'-dimethylhydrazines + 1*H*-alkyl ketones + tosic acid 560 (3079)
– 1-aminopyridinium iodides + dialkyl chlorofumarates 634 (3147)
– dialkyl phosphoroamidates + disubstituted acetaldehydes + tosic acid 692 (3188)
– diaryl phophoroamidates + disubstituted acetaldehydes + tosic acid 692 (3188)
O,*O*-diaryl phosphoroaminothioates + disubstituted acetaldehydes + tosic acid 692 (3188)
– *N*-heterocyclic compounds + (1.) sodium, (2.) acetylene 439 (2979)
Replacement of Other Substituents
– *N*-potassio-2-methoxycarbonylpyrrole + oriranes 184 (2761)
- *S*-(1-Alkenylation)
Replacement of Other Substituents
– *S*-alkyl alkanesulfinothioates + 1-alkynes 233 (2803)

● 2-Alkenylation (Allylation)
- *C*-(2-Alkenylation)
Additive 2-Alkenylation
– acetoxytropylium tetrafluoroborate + sodium cyclopentadienide 55 (2604)
Reductive 2-Alkenylation of Carbon Multiple Bonds
– methyl 2-alkynoates + 2-alkenylcopper 119 (2699)
– 2-methyl-3-oxo-1,4,4-triethylcyclopentene + allylmagnesium bromide 405
– non terminal alkenes + (1.) borane, (2.) 3-chloropropyne, (3.) methyllithium 672
Replacement of Hydrogen
– 2-alkyl-2*H*-alkanals + 1-chloro-2-alkenes + base 805 (3260)
– 2-alkyl-1,3-dithianes + (1.) butyllithium, (2.) 1,3-dichloro-2-butene 409
– alkyl 3-oxoalkanoates + (1.) sodium hydride, (2.) 1-chloro-2-pentene 407
– dimethyl 2-oxoalkanephosphonates + buthyllithium + 1,3-dichloro-2-butene 425
– ethyl 2-oxocyclopentanecarboxylate + allyl bromide 316
– phenylacetylureas + (1.) potassium amide, (2.) allyl bromide 800 (3236)
Replacement of Other Substituents
– aminomethyl phenyl sulfides + allylmagnesium halides 765
– trialkylboranes + 1-methylcyclopropene + alcohols 798 (3229)
- *N*-(2-Alkenylation)
Replacement of Hydrogen
– primary and secondary amines + 1,3-alkadienes + naphthalenesodium 431 (2944)
– alkenes containing allylic hydrogen + mercury(II) acetate 586
– alkenes containing allylic hydrogen + thallium(III) acetate 592
– alkylbenzenes + cerium(IV) ammonium nitrate 601
– alkyl ethers + lead(IV) acetate 575
– alkyl ketones + lead(IV) acetate 577
– araliphatic compounds + lead(IV) acetate 568
– arenes + acetic acid + palladium(II) salts (+ oxygen) 595
– arenes + lead(IV) acetate 573
- *S*-(2-Alkenylation)
Replacement of Halogen
– benzenesulfonyl chlorides + butadiene + copper(II) chloride 233 (2802)

● 1-Alkoxyalkylation
- *C*-(1-Alkoxyalkylation)
Replacement of Hydrogen
– radical *C*-(1,4-dioxanylation) of *N*-heteroarenes 16
– quinoxaline + diethyl ether + iron(II) sulfate + *t*-butyl hydroperoxide 16
– quinoxaline + tetrahydrofuran + iron(II) sulfate + *t*-butyl hydroperioxide 16
- *O*-(1-Alkoxyalkylation)
Replacement of Hydrogen
– 2-hydroxy-2-methylbutanone + ethoxyethylene 402

● 1-Alkoxycarbonylalkylation
- *C*-(1-Alkoxycarbonylalkylation)
Replacement of Hydrogen
– ethyl 2-oxocyclopentanecarboxylate + ethyl bromoacetate + base 316
Replacement of Other Substituents
– alkanoic acids + (1.) sulfinyldiimidazole, (2.) lithium methyl lithiomalonate 411
- *N*-(1-Alkoxycarbonylalkylation)
Replacement of Hydrogen
– *N*-(2-acylphenyl)-sulfonamides + (1.) sodium hydride, (2,) alkyl haloacetates 561 (3081)

● 2-Alkoxycarbonylalkylation
- *N*-(2-Alkoxycarbonylalkylation)
Replacement of Hydrogen
– *N*-phenylthiobenzenesulfenamide + ethyl acrylate + benzyltrimethylaminium hydroxide 228 (2784)
- *P*-(2-Alkoxycarbonylalkylation)
– methyl hypophosphite + ethyl acrylate 501 (3003)
- *S*-(2-Alkoxycarbonylalkylation)
– *S*-alky alkanesulfinothioates + ethyl acrylate 233 (2803)

● Alkoxycarbonylamination
Replacement of Hydrogen
– maleic anhydride + *N*-ethoxycarbonyliminopyridinium betaine 183 (2753)
– maleimide + *N*-ethoxycarbonyliminopyridinium betaine 183 (2753)

● Alkoxycarbonylation
- *C*-Alkoxycarbonylation
Additive Alkoxycarbonalation
– actylene + carbon monoxide + methanol + palladium chloride 520
– 1-alkynes + carbon monoxide + alcohols + transition-metal catalysts 509
– butadiene + carbon monoxide + alcohols + palladium complexes 522
– butadiene + carbon monoxide + alcohols + transition-metal catalysts 521
– butadiene + carbon monoxide + methanol + palladium complexes 521
– 3-dimethylaminopropene + (1.) methanol + palladium chloride, (2.) carbon monoxide + ethanol 522
– norbornadiene-palladium chloride complex + carbon monoxide + methanol 521
Replacement of Halogen
– alkyl halides + carbon monoxide + alcohols + tetracarbonylcobaltates 518
– benzyl chlorides + carbon monoxide + alcohols + tetracarbonylnickel 517
– bromopropene + carbon monoxide + methanol + tetracarbonylcobaltate 519
– butadiene + 3-chloropropene + carbon monoxide + alcohols + palladium salts 521
– 1-chloro-2-alkenes + carbon monoxide + alcohols + nickel catalysts 512
– 1-halo-1-alkenes + carbon monoxide + methanol + tetracarbonylnickel 517
Replacement of Hydrogen
– 1-acetyl-1-methylcyclopropane + (1.) sodium hydride (2.) diethyl carbonate 407
– ethyl 2-oxocyclopentanecarboxylate + ethyl carbonochloridate + base 316

Replacement of Other Substituents
– *t*-alkanols + (1.) formic acid/sulfuric acid, (2.) methanol 554 (3054)
– arylmercuric chorides + carbon monoxide + alcohols + palladium chloride 522
-*N*-Alkoxycarbonylation
Replacement of Hydrogen
– 4-aminobenzoic acid + benzloxycarbonyl chloride 44
– amino-acids + cyano-*t*-butyl carbonochloridate 240 (2834)
– N^{α}-protected arginine + 1-adamantyl carbonochloridate + base 122 (2708)
– sodium *N'*-arylhydrazine-*N*-sulfonates + alkyl carbonochloridates 50
● Alkoxylation
- *C*-Alkoxylation
Replacement of Halogen
– 2-acylamino-2-chloro-1,3-dioxoindanes + methanol + triethylamine 154
Replacement of Hydrogen
– alkylchloromethylnitramines + sodium alkoxides 302
- *N*-Alkoxylation
Replacement of Hydrogen
– *N*-methylcarboxamides + alcohols, electrolysis 808 (3274)
● Alkylation
- *C*-Alkylation
Additive Alkylation
– acetoxytropylium tetrafluoroborate + methyllithium 55 (2604)
– 3,4-epoxy-1-alkynes + trialkylboranes + oxygen 305
Reductive Alkylation of Carbon Multiple Bonds
- of Aldehydic or Ketonic Carbonyl Groups
– – with alkyl halides + lithium 58 (2615)
– – with dialkylcadmium 433 (2949)
– 2-acylthiophenes + 2-(1,3-dioxolan-2-yl)-ethylmagnesium bromides 819 (3314)
– 1-alkyl-3-oxoazetidines + methyllithium 153
– 1-alkyl-3-oxoazetidines + methylmagnesium iodide 153
– β-amino-ketones + alkylithium 763
– β-amino-ketones + alkylmagnesium halides 763
– aromatic aldehydes + (1.) methyllithium, (2.) lithium 175 (2719)
– aryl ketones + (1.) methyllithium, (2.) lithium 175 (2719)
– benzophenone + magnesium bromide 3-chloromagnesiopropoxide 176 (2724)
– ketones + trimethylaluminum 228 (2781)
– 2-substituted cyclobutanones + alkylmagnesium bromides 402
- of Alkenes
– alternating addition of alkyl radicals to conjugated alkenes 22
– alkyl 2,4-pentadienoates + butylcopper 807 (3267)
– butadiene + *t*-butyllithium 559 (3073)
– 1-hydroxy-2-methylcyclopentenes + pentylmagnesium bromide 404
– 3-oxocyclohexene + lithium alkylcyanocuprates 684 (3156)
- of Arenes and Hetero Analogs
– 1,3-dinitrobenzenes + alkylmagnesium halides 733
- of Carboxy Groups
– – with ethenylmagnesium chloride + copper(I) chloride 230 (2790)
– – with trimethylaluminum 228 (2781)
- of C=N Double Bonds
– 2-alkyl-5,6-dihydro-4*H*-1,3-oxazines + alkylmagnesium bromides 410
– 2-carbo-substituted 5,6-dihydro-4*H*-1,3-oxazines + alkylmagnesium halides + methyl iodide 805 (3261)
– isocyanates + alkyllithium 678
- of Cyano Groups
– alkanenitriles + 3-alkenylmagnesium bromides 408
- of Ester Carbonyl Groups
– methyl carboxylates + ethenylmagnesium chloride + copper(I) chloride 230 (2790)
Replacement of Halogen
– acyl chlorides + lithium dialkylcuprates 178 (2730)
– alkyl 4-bromo-2-alkenoates + (1.) trialkylboranes + base, (2.) alcohols 646
– 3-bromopropyne + 2-methylbutylmagnesium bromide 31
– chloroacetonitrile + (1.) trialkylboranes + base, (2.) alcohols 646
– 5-chloro-3-alken-1-ynes + methylmagnesium iodide 56 (2608)
– dialkyl-(halomethyl)-amines + trichloromethyllithium 317 (2845)
– 1-halo-1-allenes + lithium dialkylcuprates 175 (2718)
Replacement of Hydrogen
– – α-alkylation of ketones with Mannich bases 751
– – 5-methoxycarbonylpentylation of *N*-heteroarenes with cyclohexanone, hydrogen peroxide, methanol, and iron(II) sulfate 14
– –radical alkylation of protonated *N*-heteroarenes 12
– *CH*-acidic compounds + alkyl halides + quaternary aminium compounds 441
– 1-alkenes + alkyl halides + palladium(II) acetate/amines 497 (2987)
– alkoxycarbonylmethylenetriphenylphosphoranes + 1-nitro-1-alkenes 813 (3295)
– alkyl acetoacetates + (1.) sodium hydride, (2.) alkyl halides 683 (3152)
– 2-alkyl-2*H*-alkanals + alkyl chlorides + base 805 (3260)
– 1-alkyl-3-aminocarbonyl-1,4-dihydropyridines + 3-dimethylaminomethylindoles 634 (3149)
– 2-alkyl-1,3-dithianes + (1.) butyllithium, (2,) alkyl halides 403
– 1-alkynes + (1.) butyllithium, (2,) trialkylboranes 803 (3249)
– 1-alkynes, 3-step alkylation with trialkylboranes 803 (3252)
– aminoarenes + Mannich bases 753
– anilines + *t*-butyl hypochlorite + dimethyl sulfide 685 (3161)
– dialkylnitrosamines + (1.) lithium diisopropylamide, (2.) benzyl bromide 627 (3114)
– diethyl 3-ethoxycarbonyl-4-oxooctanedioate + (1.) sodium, (2.) methyl iodide 213
– diethyl 3-oxopentanedioate + (1.) sodium, (2.) 1-bromopentane 398
– 1,3-diketones + Mannich bases 752
– enamines + Mannich bases 753
– ethyl 2-oxocyclopentanecarboxylate + base + alkyl halides 316, 410
– ethyl 2-oxocyclopentanecarboxylate + dimethyl sulfate + base 316
– heterocyclic compounds + Mannich bases 753
– indene + (1.) butyllithium, (2.) alkyl halides 159
– indene + (1.) butyllithium, (2.) dimethyl sulfate 159
– 2-methyl-5,6-dihydro-4*H*-1,3-oxazines + (1.) butyllithium, (2.) 2-iodomethyl-1,3-dioxolane 410
– 2-methylfuran + (1.) butyllithium, (2.) 1-bromo-2-hexene 400
– 1-(*N*-methyl-*N*-phenylamino)-1-phenylpropene + (1.) butyllithium, (2.) methyl iodide 418
– nitroalkanes + phenolic Mannich bases 754
– 3-oxoalkanoic acid esters + Mannich bases 752
– 2-oxopropylidenetriphenylphosphorane + (1.) butyllithium, (2.) alkyl halides 59 (2619)
– phenylacetylureas + (1.) potassium amide, (2.) alkyl halides 800 (3236)
– 3-substituted 1-acetyl-2-oxo-2,3-dihydroindoles + sodium hydride + alkyl halides 815 (3303), 816 (3306)
– tertiary alcohols + dialkyl sulfate + dimsylsodium 58 (2616)
– α-(tetrahydropyranyloxy)-phenylacetonitrile + (1.) sodium hydride, (2.) 1-bromoheptane 358
Replacement of Other Substituents
– aminomethyl phenyl sulfides + alkylmagnesium halides 765
– ethyl diazoacetate + *B*-chlorodialkylboranes 118 (2695)
– 2-methoxy-3-oxocyclopentene + alkylmagnesium bromides 410
– 2-oxoalkanenenitriles + alkylmagnesium bromides 180 (2742)
– tertiary alcohols + trimethylaluminum 228 (2781)
- *N*-Alkylation
Additive Alkylation
– 3-acetoxyquinuclidine + alkyl bromides 221
– 4-alkoxypyridines + methyl iodide 227 (2778)
– 1-alkyl-1,2,3,4-tetrahydropyridine-5-carboxylic acid der. + alkyl halides 565 (3096)
– ethyl 6-diethylamino-3-methyl-4-oxohexanoate + methyl iodide 213
– 3-pyrrolidinothietanes + methyl iodide 322 (2867)
– sodium alkylnitramides + chloromethoxyalkanes 302
– sodium methylnitramide + 1-chloromethyl-4-methoxybenzene 302
Replacement of Halogen
– *N*-bromo-*N*-alkylsulfonamides + 1-alkenes + irradiation 668
– nitrosyl chloride + trialkylboranes 659
Replacement of Hydrogen
– carbazoles + alkyl halides + thallium(I) ethoxide 551 (3041)
– cyclic *N,N'*-diacylureas + lithium hydride + alkyl carbonochloridates 183 (2758)
– cyclic imides + lithium hydride + alkyl carbonochloridates 184 (2758)
– dialkylamines + styrenes + naphthalene-sodium 431 (2944)
– dibenzo[*b,f*]azepine + alkyl halides + thallium(I) ethoxide 551 (3041)

– isatin + (1.) sodium hydride, (2.) alkyl halides 816 (3307)
– phenothiazine + alkyl halides + thallium(I) ethoxide 551 (3041)
– primary amines + formaldehyde + sodium cyanoborohydride 114 (2676)
– primary amines + Mannich bases 754
– primary amines + methyl iodide + organic bases 176 (2722)
– secondary amines + formaldehyde + sodium cyanoborohydride 114 (2676)
– secondary amines + Mannich bases 754
– secondary amines + methyl iodide + organic bases 176 (2722)
- ***O*-Alkylation**
Additive Alkylation
– 3-(2-nitriloethyl)-pyridine 1-oxide + dimethyl sulfate 46
– sodium alkylnitramides + chloromethoxyalkanes 302
Replacement of Hydrogen
– – with alkyl halides in the presence of quaternary aminium compounds 447
– 2,5-dioxo-3-hydroxycyclopentanealkanoic acids + acetone dimethyl acetal 411
– N^6,5'-*O*-ditrityladenosine + benzyl bromide/base 508 (3027)
– ethyl 3-chloro-2-hydroxypropanoate + isobutene 44
– ω-hydroxyalkyl resin-carboxylates + trityl chloride + pyridine 228 (2783)
– 3-hydroxy-1-hexyne + isobutene + sulfuric acid 540
– 2-hydroxy-3-oxocyclopentene + diazomethane 410
– hydroxy-steroids + dimethyl phosphite/tosic acid 115 (2677)
– lactams + dimethyl sulfate 560 (3077)
– phenols (alkali metal salts) + dialkyl oxalates 499 (2992)
– secondary alcohols + dialkylsulfate + dimsylsodium 58 (2616)
– sodium alkoxides + Mannich base methiodides 756
- ***P*-Alkylation**
Additive Alkylation
– triphenylphosphine + Mannich bases or their methiodides 759
Replacement of Halogen
– chlorophospines + trialkylboranes 659
Replacement of Hydrogen
– dibutylphosphinous acid + (1.) lithium, (2.) 2-chloroethyl-diphenylphosphine oxide 234 (2805)
Replacement of Other Substituents
– trialky phosphites + Mannich bases 759
- ***S*-Alkylation**
Additive Alkylation
– 2,11-dithia[3.3]metacyclophanes + dimethoxycarbenium tetrafluoroborate 98
– 2-ethylthiocycloalkanones + dimethyl sulfate or methyl tosylate 631 (3135)
Replacement of Halogen
– benzenesulfonyl chlorides + ethylene + copper(II) chloride 233 (2802)
– sulfenyl chlorides + trialkylboranes 659
Replacement of Hydrogen
– alkyl 3-oxo-3-phenylpropanedithioates + alkyl halides + thallium(I) ethoxide 812 (3292)
– arenethiols + dimethyl sulfoxide + sodium cyanide 811 (3287)
– mercaptans + Mannich bases 757
Replacement of Other Substituents
– aryl thiocyanates + dimethyl sulfoxide + sodium cyanide 811 (3287)
– optically active alkyl aryl sulfoxides + alkyllithium 485
- ***Se*-Alkylation**
Replacement of Hydrogen
– benzeneselenol + formaldehyde + anilines 742
- ***Si*-Alkylation**
Replacement of Hydrogen
– alkyldiarylsilanes + alkyl halides + isopropylmagnesium chloride 558 (3071)
– aryldialkylsilanes + alkyl halides + isopropylmagnesium halides 558 (3071)
• Alkylidenation
- ***C*-Alkylidenation**
– *see also:* Carbonyl Olefination
Carbonyl-Methylene Condensation
– acetonitrile + cyclohexanone + base 179 (2737)
– 3-acetoxyindole + benzaldehydes + piperidine 236 (2816)
– alkyl cyanoacetates + 3-oxotetrahydrothiophenes 695 (3199)
– alkyl 2,2-dichloroethenyl ketones + aldehydes + tosic acid 179 (2735)
– 4-chlorophenoxyacetic acid + benzaldehydes + acetic anhydride/triethylamine 629 (3123)
– dialkyl succinates + ketones + acid 406
– ethyl acetoacetate + alkehydes + titanium(IV) chloride/base 119 (2698)
– ethyl nitroacetate + aldehydes + titanium(IV) chloride/base 119 (2698)
– isocyanomethyl 4-methylphenyl sulfone + aldehydes or ketones 62 (2634)
– 2-methoxyacrolein + formaldehyde 104
– methyl ketones + benzaldehydes + pyrrolidine/acetic acid 499 (2993)
– methyl methylthiomethyl sulfoxides + benzaldehydes + Triton B 119 (2696)
– methylnitrothiophenes + benzaldehydes + base 313
– 6-methyl-2-oxo-1,2,3,4-tetrahydropyrimidines + acetone + acid 284
– 2-oxo-4,4,6-trimethyl-1,2,3,4-tetrahydropyrimidines + benzaldehyde + base 283
Replacement of Hydrogen by Other Methods
– cyclopentadienylcopper(I)-tributylphosphine + acyl chlorides 366 (2886)
– malonic acid der. + 1-morpholinocyclohexane 803 (3248)
Replacement of Miscellaneous Substituents
– 2-lithio-2-trimethylsilyl-1,3-dithianes + aldehydes or ketones 692 (3187)
– phenylacetic acids + 3,4-dihydroxybenzaldehydes + piperidine 499 (2995)
- ***N*-Alkylidenation**
Replacement of Hydrogen
– amino-acids + 2-hydroxybenzophenones + trimethylaminium hydroxide 240 (2832)
– arylamines + *N,N*-dimethyl-3-substituted 2-propeniminium salts 69 (2661)
• Alkylthiolation
- ***C*-Alkylthiolation**
Replacement of Halogen
– 2-acylamino-2-chloro-1,3-dioxoindanes + benzylmercaptan + triethylamine 154
– alkylchloromethylnitramines + sodium alkanethiolates 303
– *S*-(1-chloroalkyl) thiocarboxylates + alkylmercaptans 812 (3293)
Replacement of Metals
– 2-carbo-substituted 2-lithio-1,3-dithianes + dimethyl disulfide 630 (3128)
Replacement of Other Substituents
– 3-alkoxy-5-alkyl-4-oxotetrahydro-1,3,5-oxadiazines + alkylmercaptans + acid 247
– 4-alkoxy-2-oxohexahydropyrimidines + alkylmercaptans + acid 264
– ethylmethyl-2-oxocycloalkylsulfonium methyl sulfates + *N*-alkylthiophthalimides 556 (3062)
– 4-hydroxy-2-oxohexahydropyrimidines + alkylmercaptans 264
– 2-oxo-4-ureidohexahydropyrimidines + alkylmercaptans 264
- ***N*-Alkylthiolation**
Additive Alkylthiolation
– dialkyl diazenedicarboxylates + dimercaptoalkanes 691 (3184)
• Alkylthiothiocarbonylation
- ***C*-Alkylthiothiocarbonylation**
Replacement of Hydrogen
– 1-cyano-3,4-dihydro-1*H*-2-benzothiapyrans + (1.) phenyllithium, (2.) carbon disulfide, (3.) alkyl iodides 297
– 1-cyanoisochromans + (1.) phenyllithium, (2.) carbon disulfide, (3.) alkyl iodides 297
• 1-Alkynylation
- ***C*-(1-Alkynylation)**
Reductive 1-Alkynylation
– 2-methoxycrolein + 1-propynyllithium 104
– 2-methylbutanal + sodium acetylenide 104
Reductive 1-Alkynylation of Carbon Multiple Bonds
– ethyl 2-methoxy-5-oxocyclopentene-1-heptanoate + 1-alkynylmagnesium bromides 404
– formaldehyde + 1-alkynylmagnesium halides 540
– ketones + 1-alkynylmagnesium halides 540
Replacement of Halogen
– alkyl bromides + sodium acetylenide 318 (2850)
– 2-(2-bromomethyl)-2-methyl-1,3-dioxolane + 1-heptynyllithium 400
– *N,N*-dialkyl-*N'*-phenylisourea chlorides + 1-alkynylmagnesium bromides 67 (2656)
– hexafluorobenzene + lithium triethylsilylacetylenide 318 (2847)
– 2-iodopyridine + 1-alkynes + copper 68 (2659)
• 2-Alkynylation
- ***C*-(2-Alkynylation)**
Reductive 2-Alkynylation of Carbon Multiple Bonds
– 2-methoxyacrolein + 2-propynyllithium 104
Replacement of Hydrogen
– 1,3-cyclohexanedione + 1-bromo-2-pentyne + base 406

• Alumination
- *C*-Alumination
Additive Alumination
– naphthalene + potassium tetraethylalanate, electrochemical reduction 386
Replacement of Other Substituents
– 3-diethylboryl-2-trimethylsilyl-2-pentene + triethylaluminum 310
– 3-ethyl-3-ethylmethoxyboryl-2-trimethylsilylpentane + triethylaluminum 310
• Amidation
- Carboxylic Acids
with Ammonia or Amines
– – with amines + EEDQ 320 (2856)
– – with amines + thionyl chloride + HMPT 434 (2957)
– – with amines + titanium(IV) chloride 118 (2693)
– – with amines + triphenyl phosphite/imidazole 320 (2856)
– – with triphenylphosphine, bromotrichloromethane, and amines 60 (2623)
– – with triphenylphosphine, carbon tetrachloride, and amines 60 (2623)
- Dithiocarboxylic Acid Esters
– 1-cyano-1-methylthiothiocarbonylisochroman + ammonia or morpholine 297
- Imidoyl Halides
– *N,N*-dimethylchloromethaniminium chloride + 2-aminobenzamide 237 (2821)
• 1-Amidoalkylation
- *C*-(1-Amidoalkylation)
Replacement of Hydrogen
– alkanoic acids + benzaldehydes + nitriles 40
– carboxylic anhydrides + benzaldehydes + carboxamides 40
– carboxylic anhydrides + benzaldehyde *N,N'*-diacylaminals 40
– 5,5-dimethyl-1,3-dioxocyclohexane + 2-acylamino-2-chloro-1,3-dioxoindanes + triethylamine 154
– quinoline + dimethylformamide + peroxy compounds 18
• Amination
- *C*-Amination
Additive Amination
– activated 1-alkenes + *N*-phenylthiobenzenesulfenamide 228 (2784)
– dialkyl 1-alkynephosphonates + primary of secondary amines 813 (3296)
– *O,O*-dialkyl 1-alkynephosphonothioates + butylamine 372 (2911)
Reductive Amination
– 3-(2-oxohexahydro-1-pyrimidyl)-propanals + ammonia + hydrogen/Raney nickel 278
– ozonolysis-hydrogenation products of alkenes + hydrogen + amines + Raney nickel 114 (2675)
Replacement of Halogen
– 2-acylamino-2-chloro-1,3-dioxoindanes + ammonia or amines + base 154
– *N*-alkyl-2-bromoalkanimines + alkylamines 178 (2733)
– 1-anilino-2-halo-1,2-diphenylethylenes + sodium azide 109
– 1-chloroanthraquinone + *N*-substituted carboxamides 432 (2948)
– 2-chloro-1,3-benzoxazole + *N,N*-dialkylhydrazines 368 (2983)
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Reductive 1-Carboxyalkylation of Carbon Multiple Bonds
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● 2-Carboxyalkylation
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– arenes + titanium(IV) chloride + peroxytrifluoroacetic acid 56 (2609)
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– 2-cyclohexyliminoalkanes + *N*-chlorosuccinimide 687 (3169)
– deserpidine + 1-chlorobenzotriazole 242 (2841)
– di-*t*-butyl-*p*-benzoquinones + chorine 688 (3171)
– diethylbenzenes + chlorine (high temperature) 680
– 1,3-dioxo-2-(2-pentynyl)-cyclohexane + *t*-butyl hypochlorite 406
– ethylbenzene + chlorine (high temperature) 680
– 2-ethylbenzonitrile + chlorine (high temperature) 680
– ethylpyridines + chlorine (high temperature) 680
– linear alkanoic acids + chlorine/sulfuric acid 22
– maleic anhydride + thionyl chloride/pyridine 497 (2986)
– maleimides + thionyl chloride/pyridine 497 (2986)
– 2-methyl-1-butene + chlorine + sodium hydrogen carbonate 146
– 2,6-unsubstituted cyclohexanones + copper(II) chloride 683 (3151)
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– alcohols + thionyl chloride 430 (2939)
– alkali metal enolates + phosphoryl chloride 111
– 1*H*-alkyl ketones + carbon tetrachloride + triphenylphosphine 684 (3155)
– allylic alcohols + dimethyl-(succinimido)-sulfonium chloride 625 (3106)
– allylic alcohols + triphenylphosphine/carbon tetrachloride 114 (2673)
– arylcarbinols + dimethyl-(succinimido)-sulfonium chloride 625 (3106)
– diethyl acetylamino-2-ethoxycarbonyl-2-hydroxyethylmalonate + thionyl chloride 46
– diphenyl-2-hydroxyethylphosphine oxide + phosphorus(V) chloride 234 (2805)
– enols + phosphorus(V) chloride 111
– 4-hydroxy-2-oxohexahydropyrimidines + thionyl chloride 270
– 3-hydroxy-3,4,4-trimethyl-1-pentyne + thionyl chloride 30, 32
Replacement of Other O-Functions
– 4-butanolide + thionyl chloride + zinc chloride 538
– cyclic orthoacetates, chlorinative cleavage with trityl chloride 689 (3175)
Replacement of Other Halogens
– ω-bromostyrene + copper(I) chloride 684 (3157)
Replacement of Other Substituents
– alkylmercaptans + (1.) chlorocarbonylsulfenyl chloride, (2.) triphenylphosphine 114 (2672)
– di-*t*-butylhalo-*p*-benzoquinones + hydrogen chloride 688 (3171)
- *N*-Chlorination
Replacement of Hydrogen
– 2,5-dioxooctahydroimidazo[4,5-*d*]imidazoles + chlorine 257
– 1,2,4-triazoles + chlorine 695 (3198)
- *P*-Chlorination

Additive Chlorination
– 2,4,6-triphenylphosphorin + chlorine 437 (2968)
- *S*-Chlorination
Chlorination involving S-S Cleavage
– bis[pentafluorophenyl] disulfide + chlorine 52
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– chloromethyl sulfoxides + chlorine 691 (3183)
● **Chlorocarbonylation**
- *C*-Chlorocarbonylation
– arylmercury compounds + palladium chloride 522
- *O*-Chlorocarbonylation
– cyano-*t*-butanol + carbonyl chloride + pyridine 240 (2834)
● **Chloromethylation**
see: 1-Haloalkylation
● **Chlorosulfonylation**
- *C*-Chlorosulfonylation
– 2*H*-alkanoic acids + sulfur trioxide + phosphoryl chloride 557 (3066)
- *N*-Chlorosulfonylation
– dialkylcyanamides + sulfuryl chloride 557 (3067)
- *O*-Chlorosulfonylation
– dihydroxyarenes + sulfuryl chloride 632 (3136)
● **Chlorothiocarbonylation**
- *O*-Chlorothiocarbonylation
– methyl 2-hydroxybenzoate, sodium salt, + thiocarbonyl chloride 325 (2878)
● **Claisen Rearrangement**
– 3-ethenyloxy-1-butyne 34
● **Curtius Degradation**
– – involving reaction of the intermediate isocyanates with organolithium compounds 678
– acyl azides, thermal degradation 413
– azidocarbonylcarboranes 660
– 3-azidocarbonyl-5-oxo-1-phenyl-4,5-dihydropyrazoles + carboxylic acids 633 (3142)
● **Cyanation**
- *C*-Cyanation
Additive Cyanation
– dimethylaminoethoxycarbenium tetrafluoroborate + sodium cyanide 61 (2631)
Reductive Cyanation of Carbon Multiple Bonds
– 1-alkyl-3-oxoazetidines + potassium cyanide (+ benzoyl chloride) 153
Replacement of Halogen
– acyl chlorides + copper(I) cyanide 181 (2743)
– alkyl halides + sodium cyanide + quaternary aminium compounds 448
– 1-anilino-2-bromo-1,2-diphenylethylenes + potassium cyanide 109
– ω-bromstyrene + copper(I) cyanide 684 (3157)
– chloroacetic acid + potassium cyanide-^{11}C 242 (2842)
Replacement of Hydrogen
– 1*H*-alkyl ketones + (1.) chlorosulfonyl isocyanate, (2.) dimethylformamide 682
– 3-(2-nitriloethyl)-1-methoxypyridinium methylsulfate + potassium cyanide 46
Replacement of Other Substituents
– adamantanone + tosylmethyl isocyanide + base 320 (2859)
– aryllithium + pentachlorobenzonitrile 555 (3058)
– arylthallium(III) salts + copper(I)- or coppper(II) cyanide 232 (2796)
● **1-Cyanoalkylation**
- *C*-(1-Cyanoalkylation)
Additive 1-Cyanoalkylation
– cyçlohexylideneacetonitrile + phenylacetonitriles + potassium *t*-butoxide 180 (2740)
Replacement of Other Substituents
– carboxylic anhydides + 1-cyanoalkylzinc bromides 120 (2700)
- *N*-(1-Cyanoalkylation)
Replacement of Hydrogen
– *N*-(2-acylphenyl)-sulfonamides + (1.) sodium hydride, (2.) chloroacetonitrile 561 (3081)
– carboxylic acid hydrazides + ketones + sodium cyanide 61 (2630)
- *O*-(1-Cyanoalkylation)
– phenols + chloroacetonitrile + base 68 (2657)
● **2-Cyanoalkylation**
- *N*-(2-Cyanoalkytion)
– anilines + acrylonitrile 698 (3213)
- *P*-(2-Cyanoalkylation)
– methyl hypophosphite + acrylonitrile 501 (3003)
● **Cycloaddition (Intermolecular)**
- [1+1+1+1] Cycloaddition
– B_2N_2 –
N-B-N-B
- *B + B + N + N*
– triallylborane + nitriles 659
- [1+1+1+1+1+1] Cycloaddition
– B_3O_3 –
O-B-O-B-O-B
- *3 B + 3 O*
– diborane + carbon monoxide 642
- [2+1] Cycloaddition
– C_2N –
- *C_2+N*
– *trans*-stilbene + 4,6-dimethyl-2-pyrimidylnitrene 135
– C_2O –
- *CO + C*
– ethyl α-lithiocarboxylates + aldehydes 234 (2807)
– ethyl α-lithiocarboxylates + ketones 234 (2807)
- *C_2 + O*
– electron-deficient olefins + cumyl hydroperoxide 64 (2642)
– C_3 –
– 2-acetoxy-1-alkenes + α-diazoketones + copper(I) compounds 401
– alkenes + chlorofluorocarbene 112
– alkenes + chloro-methylthiocarbene 209
– alkenes + dialkoxycarbonylcarbenes 138
– alkenes + dihalocarbenes 317 (2844)
– bicyclo[3.2.1]oct-2-enes + dichlorocarbene 800 (3238)
(R)-trans-cyclooctene + dibromocarbene 32
- [2+2] Cycloaddition
– C_2NO –
O-N-C-C
- *C_2 + NO*
– diphenylketene + nitrosoarenes 333
– C_2N_2 –
N-N-C-C
- *C_2 + N_2*
– diphenylketene + diphenyl diazene 334
– C_2S_2 –
S-C-S-C
- *CS + CS*
– thioaldehydes, dimerization *in situ* 117 (2687)
– thioketones, dimerization *in situ* 117 (2687)
– C_3N –
- *C_2 + CN*
– alkenes + chlorosulfonyl isocyanate 342
– diphenylketene + 2-acylamino-4,5-dihydro-1,3-thiazoles 331
– diphenylketene + *N*-acylhydrazones 331
– diphenylketene + 2-acylthio-4,5-dihydro-1,3-thiazoles 331
– 2,4-diphenyl-5-oxozolium betaines + *N*-phenylphenylmethanimine 345
– enamines + phenyl isocyanate 342
– enol ethers + sulfonyl isocyanates 342
– ketene arylimines + aryl isothiocyanates 693 (3193)
– ketene dimethyl acetals + phenyl isocyanate 341
– ketenes + 5,6-diphenyl-2,3-dihydropyrazine 332
– ketenes + imines 330
– pentafluoro-2-trifluoro-2-trifluoromethylpropene + *N*-phenylmethanimine 345
– 3-penten-4-olide + sulfonyl isocyanates 342
– phenylethynylcopper + benzaldehyde phenylnitrones 694 (3195)
– C_3O –
C_2 + CO
– 1-acylindoles + benzoic acid der. + irradiation 694 (3194)
– 1-acylindoles + benzophenone + irradiation 694 (3194)
– C_3S –
- *C_2 + CS*
– 1-pyrrolidino-1-alkenes + sulfene 322 (2867)
– C_4 –
– 1-acylindoles + activated 1-alkenes + irradiation 815 (3305)
– 2-alkenenitriles + ynamines 115 (1678)
– methylenecyclopropane + nickel(0) catalysts 427
- [2+2+1] Cycloaddition
– C_5 –
– acetylene + 3-chloropropene + carbon monoxide + water + nickel 514
– 1-chloro-2-alkenes + 1,5-hexadiene + carbon monoxide + water + nickel catalysts 515
- [2+2+1+1] Cycloaddition
– $C_2B_2N_2$ –
N-B-C-N-B-C
- *CN + CN + B + B*
– phenyl isocyanide + trialkylboranes 641
- [2+2+2] Cycloaddition
– C_3BNO –
O-B-N-C-C-C
- *C_2 + CO + BN*
– ketene + dimethyl-(dimethylamino)-borane 638
– C_3N_2O –
O-C-N-C-N-C
- *CN + CN + CO*
– dialkylcyanamides + aroyl chlorides 202
– C_4N_2 –
N-C-N-C-C-C
- *C_2 + CN +CN*
– *N,N*-dialkylenamines + phenyl isocyanate 342
– C_5O –
- *C_2 + C_2 + CO*
– butadiene + aldehydes + palladium-triphenylphosphine complex 67 (2653)
– C_4-C_4 –
– cyclobutadienetricarbonyl-iron + dimethyl acetylenedicarboxylate + cerium(IV) ammonium nitrate 667

- [3+2] Cycloaddition
– General –
– mechanism of 1,3-dipolar cycloaddition 72
– role of protic and dipolar aprotic solvents in 1,3-dipolar cycloadditions 71
– CBN_3 –
N-N-B-N-C
- $CN_2 + BN$
– benzonitrile phenylimine + phenyl-(phenylimino)-borane *in situ* 636
– CN_2OP –
O-N-C-N-P
- $CNO + NP$
– benzonitrile oxide + triphenylphosphine *N*-phenylimide 482
– CN_4 –
- $CN + N_3$
– alkyl thiocyanates + sodium azide 81
– aryl thiocyanates + sodium azide 81
– nitriles + inorganic azides 80
– nitrilium tetrafluoroborates + azide ion 235 (2811)
– C_2N_2O –
O-N-N-C-C
- $CN_2 + CO$
– diazomethane + 3,3,5-trimethylcyclohexanone 79
O-N-C-N-C
- $CNO + CN$
– nitrile oxides *in situ* + 5-phenyl-2,3-dihydro-1*H*-1,4-benzodiazepines 559 (3075)
O-C-N-N-C
- $CN_2 + CO$
– 2-phenylimino-3,4-dihydroisoquinolinium ylids + ketones 480
– C_2N_3 –
N-N-N-C-C
- $C_2 + N_3$
– alkenes + azidoarenes 77
– alkynes + tetrazolopyridine 133
– *N,N*-dimethylaminobenzenesulfonyl azide 553 (3051)
– 1-morpholinocyclohexene + tetrazoloazines 134
– ω-nitrostyrene + azidobenzene 78
- $CN_2 + CN$
– diazomethane + *N*-phenylphenylmethanimine, reaction parameters 72, 75
N-N-C-N-C
- $CN_2 + CN$
– tetrazolopyridine (→ 2-pyridylnitrene) + benzonitrile 135
– C_3NO –
O-N-C-C-C
- $CNO + C_2$
– benzaldehyde phenylnitrone + phenyl styryl sulfones 373 (2917)
– nitrile oxides *in situ* + alkenes 158
– nitrile oxides *in situ* + alkynes 158
O-C-N-C-C
- $C_2N + CO$
– alkyl 2-isocyanoalkanoates + benzaldehydes 701 (3223)
– alkyl isothiocyanates + aldehydes 375 (2926)
– alkyl isothiocyanates + ketones 375 (2926)
– C_3N_2 –
N-N-C-C-C
- $CN_2 + C_2$
– 2-arylimino-3,4-dihydroisoquinolinium ylids + alkenes 478
– *N*-(4-chloro phenyl)-*N*-(cyanoimino)-fluorene-9-iminium ylid + styrene 476
– cyclic α-diazo-ketones + alkynes 503 (3009)
– diazomethane + styrene 78
– 1-(ethoxycarbonylimino)-pyridinium ylids + dimethyl acetylenedicarboxylate 477
– primary diazoalkanes + 3-oxo-1-alkenylphosphonium bromides 236 (2815)
N-C-N-C-C
- $CN_2 + C_2$
– cyanamide + oxalyl chloride 202
– tetrazolopyridine (→ 2-pyridylnitrene) + alkynes 135
– C_3OS –
O-C-S-C-C
- $C_2S + CO$
– alkyl thiocyanatoacetates + aldehydes + base 373 (2916)
– C_3O_2 –
O-C-O-C-C
- $C_2O + CO$
– methyloxirane + cyclopentenones + tin(IV) chloride 404
– C_4N –
- $C_2N + C_2$
– azomethine ylids *in situ* + alkenes 474
– 3,4-dihydroisoquinolinium 4-nitrobenzylid + methyl acrylate 473
– 2,3-dimethoxycarbonyl-1-(4-methoxyphenyl)-aziridine + dimethyl acetylenedicarboxylate 470
– imidazolium phenacylids + ethyl propynoate 475
– pyridazinium 1-dicyanomethylids + alkynes 475
– pyridazinium phenacylids + dialkyl acetylenedicarboxylates 475
– pyridinium dicyanomethylid + dimethyl acetylenedicarboxylate 474
– pyridinium phenacylid + alkynes 473
– 1-tosylaziridine + alkyl cyanoacetates + base 546
– 1,2,3-triphenylaziridine + maleic anhydride 474
- $C_3 + CN$
– diphenylcyclopropenone + pyrazines 120 (2704)
– diphenylcyclopropenone + pyridazines 120 (2704)
– C_4O –
- $C_2O + C_2$
– α-diazo-ketones + ketene 402
– C_4S –
- $C_2S + C_2$
– dialkylidenesulfuranes *in situ* + dialkyl acetylenedicarboxylates 817 (3310)
– C_5 –
– benzoyl chloride-aluminum chloride complexes + alkynes 116 (2683)
– methylenecyclopropane + nickel(0) catalysts 427
– N_5 –
– lithium azide + aryldiazonium chlorides 79
- [3+2+1] Cycloaddition
– C_5N –
- $C_2N + C_2 + C$
– 3,4-dimethoxyaniline + ethyl propynoate 48
- [3+3] Cycloaddition
– C_3N_3 –
N-N-N-C-C-C
- $C_3 + N_3$
– triarylcyclopropylium bromides + sodium azide 325 (2875)
– C_4N_2 –
N-C-N-C-C-C
- $C_3 + CN_2$
– dimethylmalonyl chloride + cyanamide 202
– C_6 –
– methylenecyclopropane + nickel(0) catalysts 427
- [4+1] Cycloaddition
– C_3O_2 –
O-C-O-C-C
- $C_2O_2 + C$
– catechol + dialkyl acetylenedicarboxylates + base 374 (2922)
– C_4S –
- $C_4 + S$
– alkyl tetrahydro-3-thienylidene cyanoacetates + sulfur 695 (3199)
- [4+2] Cycloaddition
– C_3N_3 –
N-N-C-N-C-C
- $C_2N_2 + CN$
– benzofuroxan + disodium cyanamide 367 (2890)
– C_4NO –
O-C-N-C-C-C
- $C_3O + CN$
– dibenzoylketene *in situ* + benzylideneanilines 697
– *o*-quinone methides (*in situ* from *o*-phenolic Mannich bases) + aldimines 770
– C_4O_2 –
O-O-C-C-C-C
- $C_4 + O_2$
– 1,3-dienes + oxygen + irradiation 507 (3023)
– C_5N –
- $C_3N + C_2$
– *N*,3-diphenyl-2-propenimine + dichloroketene 332
– *N*,3-diphenyl-2-propenimine + ketenes 332
– 1,3-thiazolium 3-dicyanomethylid + dimethyl acetylenedicarboxylate 474
– C_5O –
- $C_3O + C_2$
– 2-alkenals + chloroketene dimethyl acetal 236 (2817)
– 1-alkenyl ketones + chloroketene dimethyl acetal 236 (2817)
– *o*-quinone methides (*in situ* from *o*-phenolic Mannich bases) + alkenes 770
– *o*-quinone methides (*in situ* from *o*-phenolic Mannich bases) + αH-ketones 770
– vinyl ketones *in situ* + 1-alkenes 769
– C_6 –
– 1,2-bis[methylene]-cyclohexadienes + *p*-benzoquinone 416
– 1,2-bis[methylene]-cyclohexadienes + maleic anhydride 416
– 1,2-bis[methylene]-cyclohexadienes + 1,4-naphthoquinone 416
– 1,2-bis[methylene]-cyclohexadienes + *N*-phenylmaleimide 416
– *trans*-3,4-bis[phenylethynyl]-tetraphenylcyclobutene + alkynes 783
– butadiene + vinyl ketones (from ketonic Mannich bases) 769
– 4-ethenyl-7-methoxy-1,2-dihydronaphthalene + 2,6-dimethyl-*p*-benzoquinone 117 (2690)
– 1-ethenyl-3-oxocyclohexenes *in situ* + maleic anhydride 769
– 4-ethenylpyridine + *N*-substituted maleimides 630 (3127)
- [4+3+2] Cycloaddition

– C_3N-C_3N_2O –

N-C-C-C/O-C-N-N-C-C

- C_2N_2 + C_2O + C_2

– dialkyl acetylenedicarboxylates + ketenes 334

- [5+1] Cycloaddition

– C_5N –

- C_4N + C

– 4-oxo-4*H*-3,1-benzoxazines + 1-diethylamino-1-alkynes 237 (2819)

● Cycloaddition (Intermolecular, Transannular)

→ Bicyclo[2.2.1] Systems

– C_3NO-C_4O –

O-C-N-C-C/O-C-C-C-C

- C_4O + CN

– 1,3-diphenyl-2-benofuran + 2-phenylbenzazete 694 (3196)

– C_4O-C_4O –

O-C-C-C-C/O-C-C-C-C

- C_4O + C_2

– furan + aryne derived from [2.2]-paracyclophane 102

– C_5-C_5 –

- C_5 + C_2

– cyclopentadiene + pentadienedioic acid 34

→ Bicyclo[2.2.2] Systems

– C_6-C_6 –

- C_6 + C_2

– anthracene + aryne derived from [2.2]paracyclophane 102

– [2.2]paracyclophane + tetrafluorobenzyne 103

→ Bicyclo [3.3.1] Systems

N-C-C-C-C-C/N-C-C-C-C-C

- C_8 + N

– 1,5-cyclooctadiene + *N,N*-dibromotosylamide 699 (3217)

→ Tricyclo[3.3.1.1^{3,7}] Systems (Adamantane Systems)

– C_5N-C_5N-C_5N –

- C_5N-C_5N + N

– 9-tosyl-9-azabicyclo[3.3.1]-nona-2,6-diene + *N,N*-dibromotosylamide 699 (3217)

– C_5N-C_5N-C_6 –

- C_6-C_6 + N

– bicyclo[3.3.1]nona-2,6-diene + *N,N*-dibromotosylamide 699 (3217)

– C_5N-C_5O-C_5O –

- C_5O-C_5O + N

– 9-oxabicyclo[3.3.1]nona-2,6-diene + *N,N*-dibromotosyl- , amide 699 (3217)

● Cycloaddition (Intramolecular)

- 1,3-Cyclization

– C_3 –

– 3-dialkylamino-1-oxo-1-phenylpropane, irradiation 775

- 1,4-Cyclization

– C_3N –

- C-C Ring Closure

– *N*-alkyl-*N*-phenyl-2-alkenamides + piperidine 341

– bromopiperidino-carbonylcarbene 346

– *t*-butyl 2-diazo-3-oxo-3-piperidinopropanoates, irradiation 65 (2643)

– 3-diazophenylacetyl-5,5-dimethyl-4-methoxycarbonyltetrahydro-1,3-thiazoles, irradiation 343

– 2,3-diphenylpropenamides, irradiation 344

– *N*-(2-oxoalkanoyl)-piperidines, irradiation 344

– 3-(2-oxoalkanoyl)-tetrahydro-1,3-thiazoles, irradiation 344

- 1,5-Cyclization

– CN_4 –

- C-N Ring Closure

– α-azido-*N*-heterocyclic compounds, azido-tetrazolo isomerization 123

– 3-azidopyridazine 1-oxides, deoxygenation 132

– C_3NO –

O-C-N-C-C

- C-O-Ring Closure

– α-(*N*-acetylhydrazino)-nitriles + carboxylic anhydrides 766

– 1-isocyanocycloalkanecarboxylic acids + *N*-benzylalkanimines 633 (3144)

– *N*-(2-oxoalkanoyl)-piperidines, irradiation 344

– 3-(2-oxoalkanoyl)-tetrahydro-1,3-thiazoles, irradiation 344

– C_3N_2 –

N-N-C-C-C

- C-C Ring Closure

– 1-(1,2-dialkoxycarbonylethenylimino)-pyridinium ylids, thermal cyclization 634 (3147)

N-C-N-C-C-C

- C-C Ring Closure

– hydrobenzamide + acyl chlorides + triethylamine 504 (3011)

– C_4N –

- C-C Ring Closure

– dialkyl *N*-(3-bromopropanoyl)-anilinomalonates + base 339

- C-C Ring Closure

– 2-(1-alkenyl)-3,6-dioxocyclohexadienylnitrene *in situ* 816 (3309)

– C_4O –

- C-O Ring Closure

– 4-phenyl-2,3-alkadienoic acids + bromine 33

– C_4S –

- C-S Ring Closure

– 2-acylthio-3,4-pentadienenitriles, thermally + diisopropylamine 818 (3317)

– C_5 –

– 1,4-diphenylnaphthalene-2,3-dicarboxylic anhydrides + aluminum chloride 118 (2694)

- 1,6-Cyclization

– C_3NS_2 –

S-N-C-S-C-C

- C-S Ring Closure

– styrylsulfonyl-thioureas + base 820 (3325)

– C_3N_3 –

N-N-N-C-C-C

- C-N Ring Closure

– azidotriarylcyclopropanes, thermal rearrangement 325 (2875)

– C_4NO –

O-C-N-C-C-C

- C-O Ring Closure

– 3-hydroxyalkyl isocyanides + base or copper(I) oxide 699 (3215)

– C_4NS –

S-C-N-C-C-C

- C-N Ring Closure

– 2-chlorocarbonyl-3-thiocyanatonaphthalene + hydrogen chloride 192

– C_4NSe –

Se-C-N-C-C-C

- C-N Ring Closure

– 2-selenocyanatobenzoyl chloride + hydrogen chloride 192

– C_4N_2 –

N-C-N-C-C-C

- C-C Ring Closure

– 1-chloroalkylaminocarbonyl isocyanates, thermally 237 (2820)

- C-N Ring Closure

– 5-(2-acylaminophenyl)-tetrazoles, isomerization 131

– 2-cyano-1-alkenyl isocyanates + hydrogen chloride 634 (3148)

– 2-cyanophenylcarbamoyl halides + hydrogen halide 192

– 2-cyanophenyl-thiocarbamoyl halides + hydrogen halide 192

– C_5N –

- C-C Ring Closure

– 2-biphenylyl isocyanates, irradiation 821 (3331)

– bis[3-aryl-3-oxopropyl]-amines + acid or base 767

– *N,N*-dialkyl-*N'*-phenyl-2-alkynamidines + polyphosphoric acid 67 (2656)

– 2-isopropylidenamino-biphenyls, irradiation 821 (3327)

– styryl isocyanates, thermal cyclization 186 (2769)

- C-N Ring Closure

– 2-amino-3-cyano-1-(2,2-dicyanoethenyl)-cyclopentadiene, thermal cyclization (+ base) 186 (2771)

– 4-aryl-4-cyanobutanoyl chlorides + hydrogen chloride 191

– 2-dimethylaminomethyl-3-(2-ethoxycarbonylaminophenyl)-3-oxopropene 766

– 5-nitrilo-3-alkenoyl chlorides + hydrogen chloride 191

– C_5O –

- C-C Ring Closure

– allyl aryl ethers + thallium(III) sulfate/sulfuric acid 187 (2772)

- C-O Ring Closure

– 1-(2-hydroxyphenyl)-1,3-alkadienes, thermal cyclization 564 (3091)

– C_5S –

- C-S Ring Closure

– 2-thioacyl-3,4-pentadienenitriles, thermally 818 (3317)

- 1,8-Cyclization

– C_7N –

- C-C Ring Closure

– 1-dimethylamino-3-phenylpropane, irradiation 821 (3330)

- 1,9-Cyclization

– C_8N –

- C-C Ring Closure

– 1-dimethylamino-4-phenylbutane, irradiation 821 (3330)

- [3+2] Cycloaddition

– C_4O –

- C_2O + C_2

– 3-(2-hydroxyphenyl)-3-phenylpropenes, thermal rearrangement 503 (3008)

● Cycloaddition (Intramolecular, Transannular)

→ Bicyclo [3.2.1] Systems

– C_4N-C_6 –

N-C-C-C/C6

- from 6-Membered Rings

– 1-methoxy-3-methylaminomethylcyclohexene + aluminum chloride 204

→ 6,6-Systems, fused

– C_6-C_6 –

- from 10-Membered Rings

– *anti*-8,16-dimethyl[2.2]metacyclophane-1,9-diene, thermally 98

● Cyclocondensation (Intermolecular)

→ 3 Ring Atoms

– C_2N –

- C_2 + N

– *vic*-dimesyloxyalkanes + hydrazine 438 (2974)

– C_2O –

- CO + C

– aldehydes + *gem*-dibromoalkanes + butyllithium 182 (2751)

– dialkyl ketones + dichloromethyllithium 403

– ketones + *gem*-dibromoalkanes + butyllithium 182 (2751)

– C_3 –

- $C_2 + C$
– alkenes + methyl *N*-(1-hydroxycyclohexylmethyl)-*N*-nitrosocarbamate + base 803 (3250)
– 1-bromo-2-chloroethane + 1,3-dioxo-1,2,3,4-tetrahydroisoquinolines + base 121 (2705)
– 1-bromo-2-chloroethane + 2-oxo-2,3-dihydroindoles + base 121 (2705)
– 1-hydroxy-3-methyl-2-butene + 3-chloro-3-methylbutyne + base 809 (3275)
– non-terminal alkynes + benzylidene chloride + methyllithium 611

→ 4 Ring Atoms

– C_3N –

- $CN + C + C$
– phenyl isocyanates + diazomethane 341

- $C_2 + CN$
– 2*H*-acyl chlorides + 2-aryl-5,6-dihydro-4*H*-1,3-thiazines 335
– 2*H*-acyl chlorides + 4,5-dihydro-1,3-thiazoles + triethylamine 334
– 2*H*-alkanoyl chlorides + 1-acyl-3-aryliminomethyl-indoles 336
– 2*H*-alkanoyl chlorides + imines + triethylamine 330, 334
– alkanoyl chlorides + 2-phenyl-5,6-dihydro-4*H*-1,3-thiazine 439 (2977)
– alkanoyl chlorides + 2-phenyl-4,5-dihydro-1,3-thiazole 439 (2977)
– aminoacetyl chlorides + 2-substituted 4,4,6-trimethyl-5,6-dihydro-4*H*-1,3-oxazines + triethylamine 336
– 2-chloroalkanoic acids + phosphoryl chloride + *N*-phenylarylmethanimines 338
– dichloroacetic anhydride + aldimines 337
– diethyl bromoethylmalonate + *N*-phenylphenylmethanimine + zinc 331
– 1-ethoxy-1-alkynes + imines 330
– 2-haloalkanoic acids + 2,3-bis[alkylimino]-oxetanes 340
– hetero-substituted acetyl chlorides + *N*-aryl-4-trimethylsiloxyphenylmethanimines + base 217
– hetero-substituted acetyl chlorides + *N*-(4-trimethylsiloxycarbonylphenyl)-phenylmethanimines + base 217

- $C_3 + N$
– 3-bromoalkanoyl chlorides + *O*-benzylhydroxylamine 340

– C_3S –

- $C_2 + CS$
– 1-dialkylamino-2-methylpropenes + 4-nitrophenyl phenylmethanesulfonate 534
– 1-dialkylaminopropynes + 4-nitrophenyl arylmethanesulfonates + base 534

– C_4 –

- $C_2 + C_2$
– cyclopentadiene + dichloroacetyl chloride + triethylamine 408

→ 5 Ring Atoms

– CN_4 –

- $CN + N_3$
– 2-bromopyridine + ammonium azide 84
– carboximidoyl chlorides + sodium azide 83
– 2-chloro-1,3-benzothiazole + ammonium azide 84
– 5,8-dichloropyrazino[2,3-*d*]-pyridazine + sodium azide 84

– C_2NOS –

O-N-C-S-C
- *CNOS + C*
– benzothiohydroximic acid + *N*-dichloromethylenesulfonamides 323 (2870)

- *C + C + NO + S*
– cycloalkanones + methylhydroxylamine + hydrogen sulfide + sodium hydroxide 561 (3082)

– C_2NO_2 –

O-C-O-N-C
- *CO + C + NO*
– cycloalkanones + methylhydroxylamine + sodium hydroxide 561 (3082)

O-N-C-O-C
- *CNO_2 + C*
– benzohydroximic acid + *N*-dichloromethylenesulfonamides 323 (2870)

– C_2N_2O –

O-N-C-N-C
- *CNO + CN*
– hydroximic acid chlorides + 5-phenyl-2,3-dihydro-1*H*-1,4-benzodiazepines + base 559 (3075)
– nitrile oxides *in situ* + aldazine *N,N'*-bis-oxides (aldoxime nitronates) 157

- *CN_2O + C*
– benzohydroximic acid amides + *N*-dichloromethylenesulfonamides 323 (2870)

- *C_2N + NO*
– acylaminoacetonitriles + alkyl nitrite + acid 373 (2918)
– acylaminoacetonitriles + alkyl nitrite + acid + alcohols 373 (2919)

O-C-N-N-C
- *C_2N_2 + O*
– ketone semicarbazones + lead(IV) acetate 322 (2868)

O-N-C-C-N
- *C_2NO + N*
– 4-amino-6-chloro-5-nitropyrimidines + sodium azide 136

O-S-C-C-N
- *C_2S + NO*
– 3-alkyl-1,2-dithiolium perchlorates + nitrous acid 185 (2763)

– C_2N_2P –

N-C-N-P-C
- *C_2N_2 + P*
– *N*-alkoxymethyl-*N,N'*-dialkylureas + nucleophilic tervalent phosphorus compounds 245
– alkoxymethylureas + phosphorus(III) halides 288

– C_2N_2S –

S-N-C-N-C
- *CN_2 + CS*
– 3-amino-1-iminoisoindoles + (1.) bromine/base, (2.) potassium thiocyanate 696 (3203)

S-C-N-N-C
- *C+C+N_2+S*
– cycloalkanones + hydrazine + hydrogen sulfide 561 (3082)

– C_2N_3 –

N-N-N-C-C
- *CN_2 + CN*
– alkyl-(lithiomethyl)-nitrosamines + arenecarbonitriles 633 (3141)

- *C_2 + N_3*
– 2-oxoalkylidenetriphenylphosphoranes + 1-azidoalkenes 817 (3311)

N-N-C-N-C
- *CN + CN + N*
– nitrilium tetrafluoroborates + azide ion 235 (2811)

- *CN_2 + CN*
– 1,3,4-oxadiazolium perchlorates + cyanamide + base 66 (2652)

- *C_2N + N_2*
– *N,N,N',N'*-tetramethyl-1,3-dichloro-2-azatrimethin-cyanine chloride + phenylhydrazine 440 (2980)

– C_3BO –

O-B-C-C-C
- *C_2 + CO + B*
– 1-alkynyllithium + acyl chlorides + trialkylboranes 805 (3257)

– C_3NO –

O-N-C-C-C
- *C_2 + CNO*
– 2-acetoxy-1-alkenes + nitromethyl ketones + tosic acid 561 (3084)

- *C_3 + NO*
– 5-acetyl-2-oxo-1,2,3,4-tetrahydropyrimidines + hydroxylamine 290
– 1-bromo-2-alkynes + sodium nitrite 697 (3207)

O-C-N-C-C
- *CN + CO + C*
– cyanamide + α-hydroxyphenylacetonitrile + benzaldehyde 695 (3200)

- *C_2N + CO*
– methyl isocyanoacetate + benzoyl chlorides + triethylamine 231 (2792)

- *C_2NO + C*
– 4-amino-1,3-dihydroxy-2,5,6-triphenylbenzene + ketones 502 (3006)
– aminoethanol + aldehydes + nitrous acid 633 (3145)
– 2-aminophenol + *N*-dichloromethylenesulfonamides 323 (2870)

- *C_3O + N*
– 4,5-diphenyl-2-oxo-1,3-dioxole + alkylamines 240 (2833)

– C_3NP –

N-P-C-C-C
- *C_2 + CNP*
– alkenes + alkyl *N*-dimethylphosphinocarboximidates 371 (2910)
– alkenes + dialkyl *N*-dimethylphosphinocarbimidates 371 (2910)

– C_3NS –

S-N-C-C-C
- *C_2N + C + S*
– phenylacetonitrile + dialkyl sulfites + sodium amide 65 (2646)

S-C-N-C-C
- *C_2 + CNS*
– alkynes + 2-imino-1,3-dithiolanes 439 (2978)
– α-bromo-aldehydes or ketones + ammonium (or alkylaminium) dithiocarbamates 697 (3208)
– 4,5-dialkoxy-2-oxoimidazolidines + thiourea + acid 251
– 4,5-dihydroxy-2-oxoimidazolidines + thiourea + acid 251
– methyl 3-bromo-2-oxocyclopentanecarboxylate + thiobenzamides 185 (2765)

- *C_2N + CS*
– carboxymethyl arenedithiocarboxylates + tosylmethyl isocyanide + base 235 (2809)
– *o*-chloronitrobenzenes + alkyl mercaptoacetates + triethylamine 696 (3204)
– 4-methylaniline + isothiocyanatoamine 232 (2798)

- *C_2NS + C*
– 2-aminobenzenethiol + alcohols + cyclohexene + irradiation 234 (2808)
– 2-aminobenzenethiol + *N*-dichloromethylenesulfonamides 323 (2870)

– C_3N_2 –

N-N-C-C-C

- C_2 CN_2
  - alkenes + sydnones 479
  - alkynes + sydnones 479
  - 3-oxo-1-alkenylphosphonium bromides + primary diazoalkanes 236 (2815)
- $C_3 + N_2$
  - 5-acetyl-2-oxo-1,2,3,4-tetrahydropyrimidines + phenylhydrazines + acid 290
  - 2-aminoethyl styryl ketones + phenylhydrazine 766
  - aryl trimethylsilylbutadiynyl ketones + hydrazine 47
  - 1-(chlorodimethyliminiomethyl)-2-pyrrolidinocyclohexene chloride + hydrazines 375 (2925)
  - ethyl dibenzoylacetate + hydrazine 679

N-C-N-C-C

- $C_2 + CN_2$
  - ω-bromoacetophenone + *N'*-acetylamidrazones 505 (3014)
  - 4,5-dihydroxy-2-oxoimidazolidines + ureas 254
  - 4,5-dihydroxy-2-thionoimidazolidines + thioureas 254
  - 5-hydroxy-2-oxo-2,5-dihydrofurans + *N,N'*-dialkylureas 291
- $C_2N + CN$
  - 1-anilino-2-bromo-1,2-diphenylethylenes + potassium cyanate 109
- $C_2N_2 + C$
  - *anti*-α-amino-ketoximes + carbonyl chloride + triethylamine 183 (2757)
  - 6-amino-5-nitroso-1,2,3,4-tetrahydropyrimidines + *N,N*-disubstituted formamides + phosphoryl chloride 67 (2655)
  - 6-amino-5-nitrosouracils + benzyl- (or indolylmethyl)-aminium salts 772
  - benzofuroxan + 1-nitroalkanes + amines 560 (3078)
  - benzofuroxan + nitroalkanes + ammonia 374 (2920)
  - benzofuroxans + formaldehyde 374 (2924)
  - 2,2'-bipiperidyl + aldehydes 736
  - 1,2-diaminoethanes + dimethyl *N*-cyanocarbonimidodithioate 821 (3328)
- $C_3N + N$
  - 6-alkylamino-1,3-dimethyluracils + nitrosobenzenes + acetic anhydride 817 (3313)

– C_3OP –

O-C-P-C-C

- $C_2OP + C$
  - secondary 2-hydroxyalkylphosphines + aldehydes + tosic acid 120 (2703)
  - secondary 2-hydroxyalkylphosphines + ketones + tosic acid 120 (2703)
- $C_2P + CO$
  - 2-phenylphosphinyl alkanoic acids + aldehydes or ketones 183 (2755)

– C_3O_2 –

O-C-O-C-C

- $C_2O_2 + C$
  - *vic*-diols + *N,N*-dimethylcarboxamide dimethyl acetals 187 (2774)
  - *vic*-diols + trimethyl orthoacetate 689 (3175)

– C_3SO –

O-C-S-C-C

- $C_2SO + C$
  - mercaptoacetic acid + *N*-dichloromethylenesulfonamides 323 (2870)

– C_3S_2 –

S-C-S-C-C

- $C_2S_2 + C$
  - alkane-1,2-bis[sulfenyl chlorides] + α-methylene-carbonyl compounds 120 (2701)
  - 1,2-dimercaptoethane + dichloromethyl methyl ether 65 (2645)

– C_4N –

- C_2+C+C+N
  - diphenylacetylene + carbon monoxide + nitroarenes + hexadecarbonylhexacobalt 235 (2812)
- $C_2N + C_2$
  - 2-acylaminoalkanoic acids + dimethyl acetylenedicarboxylate + acetic anhydride 473
  - 3-amino-2-alkenoic acid esters, electrolysis 503 (3010)
  - 2-amino-1-alkenyl ketones, electrolysis 503 (3010)
  - anilines + *t*-butyl hypochlorite + methylthioacetaldehyde 819 (3319)
  - anilines + *t*-butyl hypochlorite + methylthiomethyl ketones 816 (3308)
  - 1,3-oxazolium-5-oxides + alkenes 474
  - tosylmethyl isocyanide + activated alkenes + base 562 (3085)
  - 1,2,3-trisubstituted aziridines + diphenylcyclopropenone 474
- $C_3N + C$
  - 2-aminophenyl ketones + bromomethyl ketones 504 (3012)
- $C_4 + N$
  - alkyl 4-chlorobutanoates + 1-(2-aminoethoxy)-2-ethoxybenzene 438
  - 1,4-diketones + primary amines + hydrogen cyanide 735
  - *o*-phthaldialdehyde + nitrobenzenes + carbon monoxide + hexadecacarbonylhexarhodium 323 (2871)

– C_4O –

- $C_2O + C_2$
  - *CH*-acidic alkyl ketones + 1,2-alkadienyldimethylsulfonium bromides 815 (3302)
  - alkoxycarbonyloxiranes + dialkyl malonates 406
  - β-dicarbonyl compounds + 2-ethylmethylsulfonio-3-oxocycloalkene methyl sulfates + base 560 (3080)
  - phenylpropynoic acids + oxalyl chloride 695 (3201)
- $C_3 + CO$
  - methyl 2-alkenoates + primary or secondary alcohols + irradiation 632 (3140)
- $C_3O + C$
  - butyl 3-oxo-1-alkenyl sulfides + dimethylmethylenesulfurane 814 (3301)
  - *o*-phenolic Mannich base methiodides + diazomethane 773

– C_4S –

- $C_3 + CS$
  - 2-nitrobenzonitriles + alkyl mercaptoacetates + base 815 (3304), 818 (3318)
- $C_3S + C$
  - 2-acyl-3-amino-2-butenethioamides + phenacyl bromides 375 (2927)

– C_4Te –

- $C_4 + Te$
  - bis[trimethylsilyl]-butadiyne + sodium telluride 235 (2810)

– C_5 –

- $C_3 + C_2$
  - alkyl methyl ketones + dimethyl oxalate + base 410
  - 1,4-diketones + malodinitrile 186 (2771)
  - 2-oxo-2*H*-cyclohepta[*b*]furans + cyanoacetamide 55 (2605)
  - 2-oxo-2*H*-cyclohepta[*b*]furans + malodinitrile 55 (2605)
- $C_4 + C$
  - 2,3-dimethoxycarbonylpyridine + methyl ketones + base 186 (2768)

→ 6 Ring Atoms

– C_2N_3S –

S-N-C-N-C-N

- C+C+SN_2+N
  - formaldehyde + sulfamide + alkylamines 253
  - formaldehyde + sulfamide + ammonia 253

– C_2N_4 –

N-N-C-N-N-C

- $C + C + N_2 + N_2$
  - formaldehyde + *N,N'*-diphenylhydrazine 471

– C_3N_2O –

O-C-N-C-N-C

- $CN_2 + CO + C$
  - *N,N'*-dialkylureas + aldehydes + acid 246
  - *N,N'*-disubstituted ureas + formaldehyde + acid 245
  - urea + formaldehyde + alcohols 246
- $C_2N_2 + CO$
  - *N,N'*-dimethyl-*N*-methoxymethyl-urea + acetaldehyde + acid 246

– C_3N_2S –

S-N-N-C-C-C

- $C_3S + N_2$
  - 2-formylbenzenesulfonyl chloride + hydrazine 67 (2654)

S-N-C-N-C-C

- $C_3NS + N$
  - 2-chloroacetylaminodiphenyl sulfoxide + sodium azide 69 (2663)

S-N-C-C-C-N

- $C_2 + C + N_2S$
  - methyl ketones + sulfamide + hydrogen chloride 285
- $C_3 + N_2S$
  - 2-alkenals + sulfamide + acid 290

– C_3N_3 –

N-N-N-C-C-C

- *3 C + 3 N*
  - formaldehydes + carboxamides + acid 257
  - formaldehyde + sulfonamides + acid 257
- $C_3N_2 + N$
  - 2-alkylthio-4-amino-3-aminocarbonylthiophenes + nitrous acid 505 (3017)
  - 2-alkylthio-4-amino-5-aminocarbonylthiophenes + nitrous acid 505 (3017)

N-N-C-N-C-C

- $CN_2 + C + C + N$
  - nitroformaldehyde phenylhydrazones + formaldehyde + primary amines 733

N-C-N-C-N-C

- CN + CN + C + N
  - benzonitriles + carbonyl chloride 199
- $CN_2 + C + C + N$
  - guanidine + acetaldehyde + methylamine 253
  - guanidines + formaldehyde + alkylamines 251
  - thiourea + aldehydes + alkylamines 252
  - thiourea + aldehydes + ammonia 252

– urea + aldehydes + ammonia 252
– ureas + formaldehyde + alkylamines 251
- CN_2 + CN + C
– amidines + 4-oxo-2-phenyl-4*H*-1,3-benzoxazines 506 (3018)
– amidines + phenyl 2-hydroxy-benzoates 563 (3090)
– 4-oxo-2-phenoxy-4*H*-1.3-benzoxazine + *S*-alkylisothioureas + sodium alkoxides 562 (3088)
– 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine + *O*-alkylisoureas + sodium alkoxides 562 (3088)
– 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine + amidines + sodium alkoxides 562 (3088)
– 4-oxo-2-phenoxy-4*H*-1,3-benzoxazine + *N,N*-dialkyl-guanidines + sodium alkoxides 562 (3088)
- C_2N + CN + N
– *N*-(α-chlorobenzylidene)-carbamoyl chlorides + benzo-nitriles 200
- C_2N_3 + C
– N^1-arylbiguanides + diketene 536
– N^1-arylbiguanides + 2-oxo-1,3-dioxolane 666
– N^1-arylbiguanides + 2-thiono-1,3-dithiolane 666
- C_3N_2 + N
– 3,5-dialkyl-4-oxotetrahydro-1,3,5-triazines + alkylamines 247

– C_4BO –

O-B-C-C-C-C
- C_2 + C_2 + BO
– acetophenone + diethylboryl pivalate 674

– C_4N_2 –

N-C-N-C-C-C
- C_2 + CN + CN
– diethyl malonate + isocyanates + triethylamine 564 (3094)
- C_2 + CN_2 + C
– acetaldehyde + urea + acid 264, 265
– 2*H*-alkanals + guanidines + acid 262
– 2*H*-alkanals + thioureas + acid 262
– 2*H*-alkanals + thioureas + alcohols + hydrogen chloride 262
– 2*H*-alkanals + ureas + acid 262
– 2*H*-alkanals + ureas + alcohols + hydrogen chloride 262
– cyclohexanone + thioureas + acid 281
– cyclohexanone + ureas + acid 281
- C_2N + CN + C
– disubstituted acetonitriles + carbonyl chloride + hydrogen chloride 197
– α-unsubstituted alkanenitriles + carbonyl chloride + hydrogen chloride 195
- C_2N + C_2N
– 1-chloro-2-(4-nitrophenyl)-ethyl isocyanate + acetonitrile 201
- C_2N_2 + C_2
– *N*-(1-alkoxyalkyl)-thioureas + alkenes 286
– *N*-(1-alkoxyalkyl)-ureas + alkenes 286
– alkoxymethyl-thioureas + 1-alkynes + acid 286
– alkoxymethylureas + 1-alkynes + acid 286
– alkoxymethylureas + ketenes 287
- C_3 + CN + N
– malonyl chlorides + nitriles 194
- C_3 + CN_2
– 2-acetyl-4-butanolide + 2-amino-*N*-heterocyclic compounds + polyphosphoric acid 565 (3098)
– 2-alkenals + ureas + acid 289
– 1-alkenyl ketones + guanidines 289
– 1-alkenyl ketones + thioureas 281, 289
– 1-alkenyl ketones + ureas 281, 289
– butenedioic acid esters + tetrazolopyridine 134
– 1,3-dicarbonyl compounds + guanidine 258
– 1,3-dicarbonyl compounds + thiourea 258
– 1,3-dicarbonyl compounds + urea 258
– diketene + N^1-arylbiguanides 536
– 4,4-dimethyl-2-oxo-6-styryl-1,2,3,4-tetrahydropyrimidines + ureas + acid 283
– 3-formyl-5,6-dihydro-2*H*-pyrans + ureas + acid 291
– 3-hydroxybutanal + *N,N'*-dimethyl-urea + acid 289
– β-oxoaldehyde bis[dimethyl acetals] + thiourea 259
– β-oxoaldehyde bis[dimethyl acetals] + urea 259
- C_3N + CN
– 2-benzylaminomethylcyclo-alkanones + potassium cyanate 766
- C_3N_2 + C
– 2-aminobenzamide + *N*-(chloro-methylthiomethylene)-sulfonamides 326 (2879)
– 1,3-bis[benzylamino]-propanes + benzaldehydes 736
– 1,3-diamino-2-hydroxypropane + formaldehyde + 2,2-dinitro-alkanols 732
– 2-oxo-4-ureidohexahydropyrimi-dines + aldehydes + acid 265
- C_4N + N
– 3-alkoxycarbonylamino-propanals + ammonia + hydrogen/Raney nickel 279
– 3-alkoxycarbonylamino-propanals + primary amines + hydrogen/Raney nickel 279
– 3-ureidopropanals + ammonia + hydrogen/Ranay nickel 279
– 3-ureidopropanals + primary amines + hydrogen/Raney nickel 279
- C_3N_2 + C
– 2-amino-3-(3-pyrazolyl)-pyridines + triethyl ortho-carboxylates 68 (2660)
– 3-amino-4-(pyrazol-3-yl)-pyridines + triethyl ortho-carboxylates 68 (2660)
– 1,3-diaminopropanes + dimethyl *N*-cyanocarbonimidodi-thioate 821 (3328)
N-C-C-N-C-C
- C_2N + C_2N
– ethyl oxamate + α-amino-ketone dialkyl acetals (2 steps) 185 (2766)
- C_2N_2 + C_2
– benzofurazan 1-oxide + phenols + sodium methoxide 186 (2767)
– 4-hydroxy-2,5,6-triaminopyridine + 2,3-dibromopropanal + *N*-(4-amino-benzoyl)-γ-fluoroglutamic acid 46

– C_4NO –

O-N-C-C-C-C
- C_2NO + C_2 -
– α-chloro-aldehyde *N*-cyclohexyl-nitrones + alkenes + silver tetra-fluoroborate 503 (3007)
– α-chloroaldonitrones + alkenes + (1.) silver tetrafluoroborate + (2.) potassium cyanide 550 (3038)
O-C-N-C-C-C
- C_2O + C + C + N
– 4,5-dihydroxypyrimidines + formaldehyde + alkylamines 729
- C_3 + CNO -
– diphenylcyclopropenone + 1-(benzoyl-imino)-pyridinium ylid 480
- C_3N + CO -
– 2-aminopyrazine-3-carboxylic acid + carboxylic anhydrides 506 (3020)
- C_3NO + C
– 2-aminobenzoic acid + *N*-dichloro-methanesulfonamides 323 (2870)
– 3-aminopropanol + aldehydes + nitrous acid 633 (3145)
– 4-(2,6-dioxocyclohexyl)-2-oxo-hexahydropyrimidines + aldehydes + acid 249
– 2-hydroxybenzamide + benzoyl chlorides 440 (2982)
– 4-(2-hydroxyphenyl)-4-oxohexa-hydropyrimidines + aldehydes 265
– 4-(2-hydroxyphenyl)-2-oxohexa-hydropyrimidines + aldehydes 250
– 4-(2-hydroxyphenyl)-2-thiono-hexahydropyrimidines + aldehydes 265
- C_3O + CN
– 4-benzoyl-2,3-dioxo-5-phenyl-2,3-dihydrofuran + benzylideneaniline 679
– benzylmalonyl chloride + benzonitriles 193

– C_4NS –

S-N-C-C-C-C
- C_4S + N
– 2-methoxycarbonylmethylphenyl sulfoxides + hydrazoic acid 186 (2770)
S-C-N-C-C-C
- C_2 + CNS + C
– cyclohexanone + thiourea + hydrogen chloride 281
- C_3 + CNS
– 2-alkenals + thiocarboxamides + boron trifluoride 820 (3326)
– 1-alkenyl ketones + thiocarbox-amides 820 (3326)
– 1-alkenyl ketones + thioureas 289, 820 (3326)
- C_3NS + C
– 3-alkylthio-2-cyano-3-mer-captopropenamides + aldehydes or ketones 697 (3209)
– 3-alkylthio-2-cyano-3-mer-captopropenamides + carboxylic acids + polyphosphoric acid ethyl ester 819 (3321)
– 3-alkylthio-2-cyano-3-mer-captopropenethioamides + carboxylic acids + polyphosphoric acid ethyl ester 819 (3321)
– 2-aminomethylbenzenethiols + aldehydes + base 238 (2823)
– 2-aminomethylbenzethiols + ketones + base 238 (2823)

– C_4OS –

O-C-C-S-C-C
- C_2OS + C_2
– mercaptoethanol + 4,5-dialkoxy-2-oxoimidazolidines 249
– mercaptoethanol + 4,5-dihydroxy-2-oxoimidazolidines 249

– C_4O_2 –

O-C-O-C-C-C
- C_2 + CO + CO
– 4-alkyl-5-oxo-2-phenyl-4,5-di-hydro-1,3-oxazoles + aqueous formaldehyde 792
- C_3O_2 + C
– 1,3-diols + trimethyl orthoacetate 689 (3175)
O-C-C-O-C-C
- C_2O_2 + C_2
– *vic*-diols + 4,5-dihydroxy-2-oxo-imidazolidines 249

– C_4S_2 –

S-C-S-C-C-C
- $C_3S_2 + C$
– 1,3-dimercaptopropane + dichloromethyl methyl ether 65 (2645)

– C_5N –

- $C_3 + C + C + N$
– alkyl 2,4-diphenyl-3-oxobutanoates + formaldehyde + alkylamines 725
– dialkyl acetonedicarboxylates + aromatic or heteroaromatic aldehydes + alkylamines 725
– 1,3-diarylacetones + formaldehyde + primary amines 708
- $C_3 + C_2N$
– *N*-alkylcyanoacetamides + phosphoryl chloride 563 (3089)
– 1,3-dialkoxy-2-hydroxy-2-phenylpropanes + alkyl 3-aminobenzoates 505 (3016)
– diphenylcyclopropenone + 1,2-oxazoles 820 (3323)
– 3-formylpyrroles + phenylhydrazine 500 (2998)
– malonyl chlorides + α-unsubstituted nitriles 193
- $C_3N + C_2$
– 16-aminomethylene-*epi*-androsterone + 6-aminouracils 822 (3333)
– cyanoacetyl chloride, self-condensation 190
– *N,N*-dialkyl-2-cyanoalkanamides + *N,N*-dimethylphenylacetamide + phosphoryl chloride 563 (3089)
– 2,4-dioxo-1,2-dihydro-4*H*-3,1-benzoxazines + alkoxycarbonylmethylenetriphenylphosphoranes 813 (3295)
– *N,N*-disubstituted cyanoacetamides + phosphoryl chloride 563 (3089)
– 4-oxo-4*H*-3,1-benzoxazines + 1-diethylamino-1-alkynes 237 (2819)
– *N*-phenylchloromorpholinomethanimines + 2-propynylmagnesium bromide 67 (2656)
- $C_4 + C + N$
– 2-oxo-6-styryl-1,2,3,4-tetrahydropyrimidines + formaldehyde + primary amines 283
– 6-styryl-2-thiono-1,2,3,4-tetrahydropyrimidines + formaldehyde + primary amines 283
- $C_4 + CN$
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + methyl isothiocyanate 819 (3322)
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + nitriles 819 (3322)
– pyrylium perchlorates + cyanamide + base 66 (2652)
- $C_4N + C$
– 1-amino-2-phenylethanes + formic acid + polyphosphoric acid 505 (3015)
– 2-arylalkanenitriles + hydrogen chloride + carbonyl chloride 197
– histamine + 3-hydroxypyridine-4-carbaldehyde 728
– 1-(2-hydroxybenzyl)-1,2,3,4-tetrahydroisoquinolines + formaldehyde 723
- $C_5 + N$
– pentanedial + primary amines + hydrogen cyanide 735

– C_5O –

- $C_3 + C_2O$
– diarylcyclopropenones + pyridinium carbonylmethylids 480
– 2-diazoniobenzoate + 3-hydroxypyridines 375 (2929)
- $C_3O + C_2$
– 2-aminoalkyl ketones, in acetic anhydride + sodium acetate 745
– *o*-aminomethylphenols + 2*H*-alkanoic acid esters 770
- $C_4O + C$
– 2-hydroxyacetophenones + dimethylformamide + phosphoryl chloride 699 (3216)

– C_5S –

- $C_4 + CS$
– alkadiene-cyclopentadiene-(triphenylphosphine)-cobalt + carbon disulfide 819 (3322)

– C_6 –

- $C_3 + C_3$
– ethyl acetoacetate (sodium salt) + alkyl 2-alkenoates 627 (3116)
– ethyl 2-acetyl-3-methyl-2-butenoate + allyltriphenylphosphonium chloride 60 (2626)
– ethyl 6-diethylamino-3-methyl-4-oxohexanoate methiodide + ethyl 3-oxobutanoates 213
– 2-methylaminocyclohexanones + alkyl acetoacetates + base 771
- $C_4 + C_2$
– 2-alkenals + 1,4-quinones + ethoxymagnesium bromide 369 (2897)
– phthalic anhydride + 4-aminophenols (or their benzoates) 802 (3246)
→ **7 Ring Atoms**

– C_3N_4 –

N-N-C-N-N-C-C
- $C_2N_4 + C$
– 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene + paraformaldehyde 355
– 1,2-bis[*N*-methylhydrazino]-dioxocyclobutene + triethyl orthocarboxylates 355

– C_4N_2S –

S-N-C-N-C-C-C
- $C_4S + N + N$
– 2-methoxycarbonylmethylphenyl sulfoxides + hydrazoic acid 196 (2770)

– C_4N_3 –

N-C-N-C-N-C-C
- $C_2N_2 + C + C + N$
– 1,2-bis[nitramino]ethane + formaldehyde + primary amines 736

– C_4O_3 –

O-O-C-O-C-C-C
- $C_3O_3 + C$
– 3-hydroxy-*t*-alkyl hydroperoxides + acetone + tosic acid 70 (2664)

– C_5NO –

O-C-N-C-C-C-C
- $C_4NO + C$
– 4-aminobutanol + aldehydes + nitrous acid 633 (3145)

– C_5N_2 –

N-C-N-C-C-C-C
- $C_4N_2 + C$
– 2,2'-dinitrobiphenyl + aldehydes + hydrogen/palladium 326 (2882)
– 2,2'-dinitrobiphenyl + aldehydes + magnesium/hydrochloric acid 326 (2882)

N-C-C-N-C-C-C
- $C_3 + C_2N_2$
– 1,3-dioxo-1-(2-hydroxyphenyl)-3-phenylpropane + *o*-phenylenediamine 148
– 1,5-diphenyl-1,5-diaza-1*H*-pentadienium perchlorate + 1,2-diaminoethane 791
– 1,1,5,5-tetraphenyl-1,5-diaza-1*H*-pentadienium perchlorate + 1,2-diaminoethane 791

– C_5O_2 –

O-C-O-C-C-C-C
- $C_4O_2 + C$
– 1,4-diols + trimethyl orthoacetate 689 (3175)

O-C-C-O-C-C-C
- $C_3O_2 + C_2$
– 1,3-diols + 4,5-dihydroxy-2-oxoimidazolidines 249

– C_6N –

- $C_4 + C_2N$
– 2-alkoxycarbonyl-3-phenylbicyclo[2.2.0]hexanes + 2,4-diphenyl-3-methyl-5-oxy-1,3-oxazolium betaine 376 (2932)

– C_6O –

- $C_2 + C_2 + C + O$
– 1-morpholinocyclopentene + carbonyl chloride + hydrolysis 58 (2618)

– C_7 –

- $C_5 + C_2$
– 1a,5a-dihydrocyclopropa[*d*]-pyridazines + alkynes 367 (2887)
→ **8 Ring Atoms**

– C_4N_4 –

N-C-N-C-N-C-N-C
- $CN_2 + CN_2 + C + C$
– *N,N'*-dialkylureas + formaldehyde 261
- $C_2N_2 + C_2N_2$
– *N,N'*-dimethyl-*N*-methoxymethylurea + acid 261
- $C_3N_2 + CN_2$
– 3,5-dialkyl-4-oxotetrahydro-1,3,5-oxadiazines + *N,N'*-dialkylureas 247
- $C_3N_4 + C$
– *N,N',N'',N'''*-tetramethyl-*N,N'*-methylenediurea + formaldehyde 261

– C_5N_3 –

N-C-N-C-N-C-C-C
- $C_3N_2 + C + C$ ≠ *N*
– 1,3-bis[nitramino]-propane + formaldehyde + 1,ω-diaminoalkanes 736

– C_7N –

- $C_4 + C_3N$
– 1,3-diphenyl-2-benzofuran + 2-phenylbenzazete 694 (3196)

– C_8 –

- $C_4 + C_4$
– 1,3-bis[bromomethyl]-benzene + sodium 86
– 2-methyl-3-trimethylaminiomethylfurans, thermolysis 93
→ **9 Ring Atoms**

– C_8O –

- $C_6O + C_2$
– bis[2-hydroxymethylphenyl] ether + benzene + sulfuric acid 238 (2826)

– C_8S

- $C_6S + C_2$
– bis[2-hydroxymethylphenyl] sulfide + benzene + sulfuric acid 238 (2826)

– C_9 –

- $C_7 + C_2$
– 2,2'-bis[hydroxymethyl]-diphenylmethane + benzene + sulfuric acid 238 (2826)
→ **10 Ring Atoms**

– C_7NS_2 –

S-C-N-C-S-C-C-C-C-C
- $C_5 + C_2NS_2$
– 1,3-bis[bromomethyl]-benzenes + 2,6-dimercaptopyridine + base 101

– C_8N_2 –

NC-C-C-C-N-C-C-C-C

- $C_4N + C_4N$

– 2,6-bis[bromomethyl]-pyridine + sodium 90

– C_8O_2 –

O-C-C-C-C-O-C-C-C-C

- $C_4O + C_4O$

– 5-methyl-2-trimethylamino-methylfuran hydroxides, thermolysis 93

– C_8S_2 –

S-C-C-C-S-C-C-C-C

- $C_5 + C_3S_2$

– 1,3-bis[bromomethyl]-benzenes + benzene -1,3-dithiol + base 100

S-C-C-C-C-S-C-C-C-C

- $C_4S + C_4S$

– 5-methyl-2-trimethylaminio-methylthiophene hydroxide, thermolysis 93

- $C_5 + C_3S_2$

– 1,3-bis[bromomethyl]-benzene + dilithio-1,2-bis[1,3-dithian-2-yl]-benzene 92

– C_{10} –

- $C_5 + C_5$

– 1,3-bis[bromomethyl]-benzene + phenyllithium 87

– 3,5-bis[chloromethyl]-pyridines + sodium 90

– 1,3-bis[halomethyl]-2-methylbenzenes + sodium 86, 87

- $C_6 + C_4$

– 2,2'-bis[triphenylphosphoranylidene-methyl]-biphenyl + 1,2-bis[bromo-methyl]-arenes 92

– 2,2'-bis[triphenylphosphoranyli-denemethyl]-biphenyl + *o*-phthaldial-dehyde 92

→ **11 Ring Atoms**

– C_{11} –

- $C_6 + C_5$

– 1,4-bis[bromomethyl]-benzene + dilithio-1,3-bis[1,3-dithian-2-yl]-benzene 91

→ **12 Ring Atoms**

– $C_{10}S_2$ –

- $C_5S_2 + C_5$

– 1,3-bis[mercaptomethyl]benzene + 1,3-bis[bromomethyl]benzene + base 97

– C_{12} –

- $C_4 + C_4 + C_4$

– 1,3-bis[bromonethyl] benzene + sodium 86

- $C_6 + C_6$

– 1,4-bis[bromodifluoromethyl]-benzene, thermolysis 96

– 9,10-bis[halomethyl]-anthracenes + sodium iodide 96

– 1,4-bis[tosyloxy]-1,4-dihydro-naphthalene, solvolysis 96

– 3,6-bis[tosyloxymethyl]-1,4-cyclohexadiene, solvolysis 95

– 2,2'-bis[triphenylphosphoranyl-idenemethyl]-biphenyl + 2,2'-bis[bromomethyl]-biphenyl 92

– 4-methylbenzyltrimethylaminium hydroxide, Hofmann elimination 93

– 4-methyl-1-trimethylaminio-methylnaphthalene hydroxide, thermolysis 96

→ **14 Ring Atoms**

– C_8N_6 –

- $C_4N_4 + C_4N_2$

– 2,9-diamino-1,10-phenanthroline + 2,9-dichloro-1,10-phenanthroline 64 (2640)

– C_{14} –

- $C_7 + C_7$

– 2,7-bis[bromonethyl]-naphthalene + sodium 89

→ **16 Ring Atoms**

– C_{16} –

- $C_8 + C_8$

– 1,2-bis [2-bromomethylphenyl]-ethane + phenyllithium 86

→ **20 Ring Atoms**

– C_{20} –

- $5 \times C_4$

– 1,3-bis[bromomethyl]-benzene + sodium 87

→**Bicyclo[2.2.1] Systems**

– C_3N_2-C_3N_2 –

N-C-N-C-C/N-C-N-C-C

- $C_2N + C_2N + C$

– bis[2-chloroethyl]-amine + formaldehyde 708

→ **Bicyclo[3.3.1] Systems**

– C_4N_2-C_4N_2 –

N-C-N-C-C-C/N-C-N-C-C-C

- $CN_2 + CN_2 + C + C + C$

– urea + semiacetal chlorides + dimethylformamide + carbonyl chloride 258

- $C_3 + CN_2 + CN_2$

– 1,3-dicarbonyl compounds + ureas 257

– C_5N-C_5N –

N-C-C-C-C-C/N-C-C-C-C-C

- $C_3 + 4C + N + N$

– 1,3-diarylacetones + formaldehyde + primary amines 708

→ **Spiro[5.5] Systems**

– C_4N_2-C_4N_2 –

N-C-N-C-C-C/N-C-N-C-C-C

- $C_3 + CN_2 + CN_2 + C + C$

– acetone + urea + hydrogen chloride 285

- $C_5 + CN_2 + CN_2$

– bis[1-alkenyl] ketones + thiourea + acid 291

– bis[1-alkenyl] ketones + ureas + hydrogen chloride 291

→ **5,5-Systems, fused**

– C_3N_2-C_3N_2 –

N-C-N-C-C/N-C-N-C-C

- $C_2 + CN_2 + CN_2$

– *vic*-dicarbonyl compounds + guanidines, thioureas, or ureas 254

– C_5-C_5 –

- $C_4 + C_2 + C_2$

– 1,4-diketones + malodinitrile (2 steps) 186 (2771)

→ **5,6-Systems, fused**

– C_2N_3-C_5N –

N-N-N-C/N-C-C-C-C

- $C_6 + N_3$

– 27-*O*-tosylpseudodiosgenin + potassium azide 84

– C_3NO-C_4NO –

O-C-N-C-C/O-C-N-C-C-C

- $C_5NO + CO$

– 4-(2-hydroxyalkylamino)-2-phenylpyrimidine-5-carboxylic acids + acetic anhydride 633 (3143)

– C_3NS-C_4N_2 –

S-C-N-C-C/N-C-N-C-C-C

- $C_4NS + C_2N$

– alkyl 2-isothiocyanatobenzoates + 3-amino-1-alkynes 426

– C_3N_2-C_4N_2 –

N-C-N-C-C/N-C-N-C-C-C

- $C_4N + C_2N_2$

– 2,4-dithiono-1,2-dihydro-4*H*-3,1-benzothiazines + 1,2-diamino-ethane 506 (3021)

– C_4N-C_5N –

N-C-C-C-C/N-C-C-C-C-C

- $C_5N + C_2 + N$

– 4-benzylidene-2,3-dioxopyrro-lidines + ethyl acetoacetate + ammonia 609

– 4-benzylidene-2,3dioxopyrro-lidines + 1-phenacylpyridinium bromide + ammonium acetate 609

- **5,7-Systems, fused**

– C_4O-C_7 –

O-C-C-C-C/C7

– benzyl methyl diazomalonates, thermolysis 144

→ **6,6-Systems, fused**

– C_3N_3-C_3N_3 –

N-C-N-C-N-C/N-C-N-C-N-C

- $C_2N_3 + C_2N + C$

– 2,6-diaminopyridine + alkyl *N*-cyanoalkanimidates 376 (2930)

– C_4NO-C_4N_2 –

O-C-N-C-C-C/N-C-N-C-C-C

- $C_4O + CN_2 + C + C$

– bis[1-chloro-2-methylpropyl] ether + urea 265

– C_4NO-C_5O –

O-C-N-C-C-C/O-C-C-C-C-C

- $C_3O_2 + C_3 + CN$

– malonyl chloride + nitriles 192

– C_4N_2-C_4N_2 –

N-C-N-C-C-C/N-C-N-C-C-C

- $C_2 + CN_2 + CN_2 + C + C$

– 2*H*,2*H*-alkanals + *N*,*N*'-disubstituted ureas + acid 265

- $C_2N_2 + C_2N_2 + C_2$

– alkoxymethyl-thioureas + 1-alkynes + acid 286

– alkoxymethylureas + 1-alkynes + acid 286

- $C_4 + CN_2 + CN_2$

– 1-hydroxy-2-hydroxymethyl-3-oxo-butane + ureas 291

→ **6,6,6-Systems, fused**

– C_5N-C_2N_4-C_5 –

- $C_5 + C_5 + N_2 + N_2$

– 2-(2-chloroethyl)-benzaldehyde + hydrazine 471

→ **Tricyclo[3.3.1.1^{3,7}] Systems (Adamantane Systems)**

– C_2N_3S-C_2N_3S-C_2N_3S –

- $4C + N_2S + N_2S$

– formaldehyde + sulfamide + acid 261

– C_2N_3S-C_2N_3S-C_3N_3 –

- $4C + SN_2 + N + N$

– formaldehyde + sulfamide + ammonia 253

– C_4N_2-C_4N_2-C_5N –

- $C_3 + 5C + N + N$

– 1,3-diarylacetones + formal-dehyde + ammonia 708

→ **Tricyclo[3.3.2.1^{3,7}]Systems**

– C_2N_3S-C_2N_3-C_4N_3 –

- $C_2N_2 + 3C + SN_2$

– 1,2-diaminoethane + formaldehyde + sulfamide 253

● **Cyclocondensation (Intermolecular, Transannular)**

→ **5,5,6,6-Systems, fused**

– C_4N-C_4N-C_4N_2-C_4N_2 –

- $C_{12} + N_2$

– 3,6,9,12-tetraoxo-1,7-cyclododeca-diene + hydrazine + oxygen 102

→ **Bicyclo[3.2.1] Systems**

– C_3N_2-C_4N_2 –

N-C-N-C-C/N-C-N-C-C-C

- C_3N_2 *(+C)* + C_2

– 1-hydroxymethyl-2-oxoimidazolidines + α-branched aldehydes 278

→ **Bicyclo[3.3.1] Systems**

– C_4N_2-C_4N_2 –

N-C-N-C C-C/N-C-N-C-C-C

- C_4N_2 *(+ C)* + C_2

– 1-hydroxymethyl-2-oxohexahydro-pyrimidines + α-branched aldehydes 278

– C_5N-C_5N –
N-C-C-C-C-C/N-C-C-C-C-C
- *C_5N + C + C + N*
– 3,5-dialkoxycarbonyl-4-oxopiperidines + formaldehyde + primary amines or ammonia 725

– C_5N-C_5O –
O-C-C-C-C-C/N-C-C-C-C-C
- *C_5O + C + C + N*
– 3,5-dialkoxycarbonyl-4-oxotetrahydropyrans + formaldehyde + primary amines 725

– C_5N-C_5S –
S-C-C-C-C-C/N-C-C-C-C-C
- *C_5S + C + C + N*
– 3,5-dialkoxycarbonyl-4-oxothiacyclohexanes + formaldehyde + primary amines 725

– C_5N-C_6 –
N-C-C-C-C-C-/C6
- *C_6 + C + C + N*
– 3,4-di-*aci*-nitrocyclohexenes + formaldehyde + primary amines 733
– 2-oxocyclohexanecarboxylic acid der. + formaldehyde + alkyl amines 725
→ **Bicyclo[4.3.1] Systems**

– C_5N-C_7 –
N-C-C-C-C-C-C/C7
- *C_7 + C + C + N*
– 2,4-dialkoxycarbonyl-1,5-dioxo-2,3,4,5-tetrahydro-1*H*-benzocycloheptenes + formaldehyde + alkylamines 725
→ **Bicyclo[8.2.1] Systems**

– C_4N-$C_{10}N$ –
- *C_{12} + N*
– 1.4-dioxocyclododecane + ammonia 101

– C_4S-$C_{10}S$ –
- *C_{12} + S*
– 1.4-dioxocyclododecane + hydrogen sulfide 101
→ **Tricyclo[3.3.1.1^{3,7}] Systems (Adamantane Systems)**

– C_5S-C_5S-C_5N –
- *C_5N-C_5N + S*
– 9-formylbicyclo[3.3.1]nona-2,6-diene + sulfur dichloride 375 (2928)
→ **Tricyclo[8.2.1.^{4,7}] Systems**

– C_4N-C_4N-C_8N_2 –
- *C_{12} + N + N*
– 1,4,7,10-tetraoxocyclododecane + methylamine 102

● **Cyclocondensation (Intramolecular)**
- **General (C→C)**
Elimination of Hydrogen Halide
– dimethyl α,α'-dibromoalkanedioates + sodium hydride 628 (3119)
Elimination of Water
– 3-anilinopropanoic acids + polyphosphoric acid 698 (3213)
– 2-arylaminoethyl ketones + polyphosphoric acid 767
– 1,4-diols + tosic acid 696 (3206)
– 2-hydroxy-3-phenylalkyl ketones + polyphosphoric acid 620
- **1,3-Cyclization**

– C_2O –
- *C-O Ring Closure*
– *vic*-halostannyloxyalkanes, thermolysis 64 (2642)

– C_3 –
– 2-chloromethyl-1-butene + potassium amide 146
– 1-chloro-2-methyl-2-butene + sodium amide 146
– 2-chloromethyl-1-butene + sodium amide 146
- **1,4-Cyclization**

– C_3N –
- *C-C Ring Closure*
– *N*-aryl-*N*-phenacylhaloacetamides + base 339
– dialkyl *N*-acetylanilinomalonates + base 339
– (1,1-dibromo-2-oxo-2-piperidinoethyl)-phenylmercury, thermolysis 346
- *C-N Ring Closure*
– β-alkylaminoacyl chloride hydrochlorides + ammonia or amines 328
– alkyl 3-aminoalkanoates + alkylmagnesium halides 329
– 3-aminoalkanoic acids + carbonyl compounds + isocyanides 345
– 5-amino-4-methoxycarbonyltetrahydro-1,3-thiazoles + triisobutylaluminum 329
– 2-(1-carboxyethyl)-5,5-dimethyl-2,5-dihydro-1,3-thiazole + isocyanides 345
– 3-haloalkanamides + base 340
– 2-phenylpropanamides + sodium amide 340
– substituted tetrahydro-1,3-thiazole-2-acetic acids + dicyclohexylcarbodiimide 328

– C_3Si –
- *C-Si Ring Closure*
– chloro-3-chloropropylsilanes + magnesium 437 (2971)

– C_4 –
– dimethyl 2,5-dibromohexanedioate + sodium hydride 628 (3119)
- **1,5-Cyclization**

– C_2NO_2 –
O-O-C-N-C
- *C-O Ring Closure*
– *N*-benzoylcarbamoperoxoic acids + carboxylic acids 236 (2813)

– C_3NO –
O-N-C-C-C
- *C-O Ring Closure*
– β-trialkylamino-ketoxime iodides + base 772
O-C-N-C-C
- *C-O Ring Closure*
– α-benzoylaminophenylacetic acids + acetic anhydride 470
– *N*-(2-hydroxyalkyl)-carboxamides + zinc acetate 183 (2754)
– *N*-phenacylbenzamides + hydrogen fluoride 817 (3312)

– C_3NS –
S-N-C-C-C
- *C-C Ring Closure*
– *N*-(2-bromoalkyl)-*N*-methylalkanesulfonamide + butyllithium 668
S-C-N-C-C
- *C-N Ring Closure*
– *S*-(2-oxoalkyl) *N*-phenylcarbamoselenothioates + acid 236 (2814)

– C_3N_2 –
N-C-N-C-C
- *C-N-Ring Closure*
– aldehyde 1-cyanoalkylnitrones + benzenethiols 374 (2923)
– 2-azido-1-benzylidenamino-4-dimethylaminobenzenes, thermally 299
– 2-nitroanilinoacetonitriles + base 695 (3202)

– C_4N –
- *C-C Ring Closure*
– *N*-(2-acylphenyl)-*N*-(functionally substituted methyl)-sulfonamides + base 561 (3081)
– anilinotetrachloropyridines, irradiation 372 (2915)
– 2-benzyl-1-phenacylpyridinium bromides + pyridine 238 (2825)
- *C-N Ring Closure*
– 2-(1-alkenyl)-3-azido-*p*-benzoquinones, thermolysis 816 (3309)
– 2-amino-α-methylthiophenylacetaldehyde dimethyl acetals + acid 819 (3319)
– 2-dialkylaminoethenyl phenyl ketones, photochemically 66 (2651)
– maleic acid mono-(*N*-phenylamides) + 1-hydroxybenzotriazole + dicyclohexylcarbodiimide 484

– C_4O –
- *C-C Ring Closure*
– 2-alkoxymethyl-1,1-dibromocyclopropanes + methyllithium 185 (2762)
– phenoxytetrachloropyridines, irradiation 372 (2915)
- *C-O Ring Closure*
– 1-alkyl 2-alkylidenesuccinates + acid 406
– 1-amino-4-hydroxy-1-alkenes, thermally 418
– 1,6-bis[hydroxymethyl]-tetracyclo[4.4.0.0^{2,5}.0^{7,10}]deca-3,8-diene + tosyl chloride/pyridine 667
– 3-bromomethyl-2-alkenoic acids or esters + iron 502 (3005)
– diethyl 2-halo-1-oxoalkylmalonates + triethylamine 184 (2760)
– 1,4-diols + tosic acid 696 (3206)
– 2,5-dioxohexane + Amberlyst 15 209
– 1-(diphenylhydroxymethyl)-2-trialkylaminiomethylferrocenes + sodium/ammonia 773
– 4-formyloxybutanal + trialkyl orthoformates + acid 66 (2647)
– phthaloyl chloride + tertiary phosphines 322 (2868)

– C_4S –
- *C-C Ring Closure*
– phenylthiotetrachloropyridines, irradiation 372 (2915)

– C_5 –
– 2-alkyl-3-chloro-2-(2-oxoalkyl)-oxiranes + aqueous-methanolic barium hydroxide 403
– 2-amino-3-cyano-1-(2,2-dicyanoethenyl)-cyclopentadiene + base 186 (2771)
– 2-aryl-1-(2-hydroxymethyl)-ethanols + polyphosphoric acid 548 (3031)
– diethyl 3,6-dioxododecanedioate + base 408
– diethyl 3-methyl-2-(2-pentenyl)-2-hexenedioate + sodium 398
– 3,7-dihydroxy-3,7-diphenyl-2,2,8,8-tetramethyl-4-nonyne + (+)-bromocamphorsulfonic acid 29
– dimethyl 2,6-dibromoheptanedioate + sodium hydride 628 (3119)
– 2,5-dioxoalkanes + base 400, 409
– 7,10-dioxo-3-undecene + base 408
– 7,10-dioxo-3-undecyne + base 401
– 12-ethyl 4-oxododecanedioate + aluminum chloride 404
– 4-oxoalkanals + base 411
– 2-oxocyclopentanebutanoic acid + polyphosphoric acid 627 (3117)
– 3-oxo-2-(2-oxopropyl)-alkanoic acid esters + base 398
– 3,3,3-triphenylpropene + palladium(II) acetate/acetic acid 531
- **1,6-Cyclization**

– C_3N_2O –

O-C-N-N-C-C

- C-O Ring Closure

– *N,N'*-diacyl-*N*-(2-hydroxyphenyl)-hydrazines + base 564 (3092)

O-C-N-C-N-C

- C-O Ring Closure

– *N,N'*-bis[hydroxymethyl]-ureas + acid 245

– C_3N_2S –

S-N-N-C-C-C

- S-N Ring Closure

– 1-hydrazonomethyl-2-thiocyanato-cycloalkenes + perchloric acid 225

S-C-N-N-C-C

- C-N Ring Closure

– 2-arylhydrazono-1-thiocyanato-alkanes + perchloric acid 226

– C_3N_3 –

N-N-N-C-C-C

- C-N Ring Closure

– 1-alkyl-3-(2-ethoxycarbonylphenyl)-triazenes, thermally 237 (2822)

N-N-C-N-C-C

- C-N Ring Closure

– 2-(1-acylhydrazonoalkyl)-pyrroles + base 698 (3212)

– 6-(1-alkoxycarbonylethylidene-hydrazono)-tetrazolo[1,5-*b*]-pyridazines + polyphosphoric acid 133

N-C-N-C-N-C

– *N,N'*-alkylidene-bis-ureas, thermally 257

– C_4NO –

O-C-N-C-C-C

- C-N Ring Closure

– *O*-(2-methoxycarbonylphenyl) *N*-aryl-thiocarbamates + acid 325 (2878)

- C-O Ring Closure

– alkyl *N*-(3-hydroxypropyl)-carbamates, thermally 279

– 3-hydroxypropylureas, thermally 279

– 3-ureidoalkonoic acids, thermally 279

O-C-C-N-C-C

- C-O Ring Closure

– *N*-aryl-*N*-(3-nitrophenacyl)-haloacetamides + triethylamine 339

– 2-carboxy-1-(2-hydroxy-2-phenyl-ethyl)-pyrrole + polyphosphoric acid 184 (2761)

– C_4NS –

S-N-C-C-C

- C-N Ring Closure

– 2-diazoacetylbenzenesul-fonamides + formic acid 506 (3019)

S-C-N-C-C-C

- C-N Ring Closure

– 2-thiocyanatobenzoic acids + phosphorus(V) chloride 191

– C_4N_2 –

N-C-N-C-C-C

- C-N Ring Closure

– *N*-acyl-*N'*-arylureas + polyphosphoric acid 325 (2877)

– *N*-(2-aminocarbonylphenyl)-*S*-methyl-*N'*-tosylisothioureas, thermally 326 (2879)

– 1,3-bis[alkoxycarbonylamino]-propanes + base + heat 286

– *N*-(2-cyanophenyl)-*N',N'*-dimethyl-formamidinium chloride + ammonia or primary amines 237 (2821)

– *N*-(3-hydroxy-1-alkenyl)-ureas + acid 245

N-C-C-N-C-C

- C-N Ring Closure

– *N*-(2,2-dialkoxyalkyl)-oxamates + acid 185 (2766)

– C_4OS –

O-C-S-C-C-C

- C-O Ring Closure

– alkyl 2-carboxyphenyl sulfoxides + acetic anhydride 507 (3024)

– C_5N –

- C-C Ring Closure

– 3-anilinopropanoic acids + polyphosphoric acid 698 (3213)

– 2-arylaminoethyl ketones + acid 767

– benzylaminoacetaldehyde dialkyl acetals + acid 769

– 1-chloro-2-(2,6-dimethylphenyl)-ethenyl isocyanates + hydrogen chloride + heat 201

– diethyl *N*-arylaminomethylene-malonates + phosphorus pentoxide 325 (2876)

- C-N Ring Closure

– 5-alkylaminoalkanols + Raney nickel 440 (2983)

– *N*-chloro-3-phenylpropyl-amines + iron(II) sulfate 9

– 2-cyanomethylbenzoic acid + phosphorus(V) chloride 190

– C_5O –

- C-O Ring Closure

– 1-amino-5-hydroxy-1-alkenes, thermally 418

– 1,5-dihydroxypentane + Amberlyst 15 209

– 3-(1-dimethylaminoalkylidene)-2-(hydroxyphenyl)-4-phenyl-3*H*-1,5-benzodiazepine, thermally on ion-exchange resin 148

– 4-hydroxy-3-(2-hydroxybenzyl)-coumarins + phosphoryl chloride 754

– 3-hydroxy-3-(2-hydroxyphenyl)-1-alkenes, thermal cyclo-dehydration 562 (3086)

– C_6 –

– 1-(2-alkoxycarbonyl-3,6-dimethoxy-phenyl)-2-methoxynaphthalenes + hydrogen fluoride 319 (2855)

– benzylidenediphenylmethylene-succinic anhydrides, irradiation 118 (2694)

– dimethyl 2,7-dibromooctanedioate + sodium hydride 628 (3119)

– dimethyl 2,6-dioxoalkenephosphonates + sodium hydride 425

– 3-ethoxycarbonyl-7-methoxy-2-(3-oxo-1,3-dihydrobenzo[*c*]furan-2-yl)-1,4-naphthoquinone + boron trifluoride etherate 319 (2854)

– 2-hydroxy-3-phenylalkyl ketones + polyphosphoric acid 620

- 1,7-Cyclization

– C_7 –

– dimethyl 2,8-dibromononane-dioate + sodium hydride 628 (3119)

- 1,10-Cyclization

– C_8N_2 –

N-C-C-C-C-N-C-C-C-C

- C-C Ring Closure

– 1,2-bis[6-bromomethyl-2-pyridyl]-ethyne + organolithium compounds 90

– 1,2-bis[6-lithiomethyl-2-pyridyl] ethane + copper(I) halides 91

– C_9N –

- C-C Ring Closure

– 6-bromomethyl-2-[2-(3-bromo-methylphenyl)-ethyl]-pyridine + butyllithium 90

– C_{10} –

– 2,3-bis[3-bromomethylphenyl]-butane + sodium 88

– 1,2-bis[3-bromomethyl-2-methyl-phenyl]-ethane + sodium 86

– 3,3'-bis[bromomethyl]-stilbenes + phenyllithium 88

– 3-bromomethyl-5-[2-(3-bromo-methyl-2-methylphenyl)-ethenyl]-2,4,6-trimethylpyridine + phenyl-lithium 90

- 1,12-Cyclization

– C_{12} –

– 1-(4-bromomethylphenyl)-2-(4-bromomethyltetrafluoro-phenyl)-ethane + sodium 95

– 1,2-bis[4-bromomethylphenyl]-ethanes + sodium 89

- [3+2] Cyclization

– C_3N_2 –

N-C-N-C-C

- C_2N_2 + C

– *N,N*-dialkyl-*N'*-(2-nitro-phenyl)-hydrazines + acid 694 (3197)

– C_4N –

- C_2N + C_2

– *N*-acyl-*N'*-(1-alkenyl)-*N,N'*-dimethylhydrazines + sodium methoxide 560 (3079)

→ 6,6-Systems, fused

– C_3N_3-C_4N_2 –

N-C-N-C-N-C/N-C-N-C-C-C

- C-N, C-N Ring Closure

– 2-acylamino-6-(3-nitrilopro-penylamino)-pyridines, cyclodehydration 324 (2873)

– C_6-C_6 –

– 3,3'-bis[bromomethyl]-benzene + sodium 88

● Cyclocondensation (Intramolecular, Transannular)

→ Bicyclo[2.2.2] Systems

– C_6-C_6 –

- from 6-Membered Rings

– 3-oxocyclohexaneacetic acid + acetic acid/polyphosphoric acid 231 (2794)

→ Bicyclo[8.2.1] Systems

– C_4O-$C_{10}O$ –

- from 12-Membered Rings

– 1,4-dioxocyclododecane dehydration 101

→ Tricyclo[3.3.1.1^{2,6}] Systems (Twistane Systems)

– C_5O-C_5O-C_5O –

- from Bicyclo[3.3.1] Systems

– 2-hydroxy-6-iodo-9-oxabicyclo-[3.3.1]nonane + pyridine 376 (2931)

● Cyclodehydrogenation (Intermolecular)

→ 3 Ring Atoms

– C_2N –

- C_2 + N

– alkenes + *N*-aminophthalimide + lead(IV) acetate 438 (2975)

→ 5 Ring Atoms

– C_3S_2 –

S-S-C-C-C

- C_3 + S + S

– 6-methyl-2-oxo-1,2,3,4-tetrahydro-pyrimidines + sulfur 276

– 6-methyl-2-thiono-1,2,3,4-tetra-hydropyrimidines + sulfur 276

→ Tricyclo[3.3.1.1^{2,6}] Systems (Twistane Systems)

– C_6-C_6-C_6-C_6 –

- C_6 + C_4

– 2,4,6-trimethylphenol + 2-bromomethylbutadiene + sodium hydride 802 (3247)

● Cyclodehydrogenation (Intramolecular)

- 1,5-Cyclization

– C_2N_3 –

N-N-C-N-C

- C-N Ring Closure

– 2-benzylidenehydrazino-1,3-benzothiazoles + bromine/sodium carbonate 66 (2650)

– C_3N_2 –

N-N-C-C-C

- C-C Ring Closure

– 6-benzylidenehydrazino-2,4-dioxo-1,2,3,4-tetrahydropyrimidines, thermally 300

– C_3S_2 –

S-S-C-C-C

- S-S Ring Closure

– 2-carboxy-1,3-dimercaptopropane + dimethyl sulfoxide 607

– dialkyldithiomalonic acids + iodine 559 (3074)

– C_4O –

- C-O Ring Closure

– linear alcohols + cerium(IV) ammonium nitrate 348

– linear aldanols + lead(IV) acetate 406

- 1,6-Cyclization

– C_5N –

- C-C Ring Closure

– *N*-aryl-2-propenimines, thermally 69 (2661)

– 2-(3-oxobutyl)-2-azabicyclo-[2.2.2]octane + mercury(II) acetate 769

- C-N Ring Closure

– 2-ethylbenzonitrile + chlorine 680

– C_5O –

- C-O Ring Closure

– *N*-acyl-3,4-dihydroxyphenyl-L-alanine + iodosobenzene diacetate 562 (3087)

– C_6 –

– 1,2-diethylbenzene + chlorine 680

- [3+2] Cyclization

– C_3NO –

O-C-N-C-C

- C_2O + CN

– 3-aminoalkanamides + lead(IV) acetate/pyridine 818 (3316)

● Deacylation

- *N*-Acyl Derivatives

Solvolytic Deacylation

– *N'*-acetyl-*N,N'*-dialkylhydrazine, acidic hydrolysis 497 (2984)

– 1-acetyl-3,3-dialkyl-2-oxo-2,3-dihydroindoles + potassium hydroxide/ethanol 816 (3306)

Miscellaneous Methods

– 1-phthalimidoaziridines + hydrazine 438 (2975)

● Dealkoxycarbonylation

– diethyl 2,5-dioxocyclohexane-1,4-dicarboxylate + tosic acid + ethylene glycol 665

– 1-ethoxycarbonyl-3-formylpyrrole + aqueous-methanolic sodium hydroxide 422

– 2-ethoxy-3-ethoxycarbonyl-4-oxo-4,5-dihydrofurans + aqueous potassium- or barium hydroxide 184 (2760)

● Dealkylation

- *N*-Alkyl Compounds

Chemical Dealkylation

– 3-acetoxy-1-alkylquinuclidinium bromides + hydrogen/palladium on carbon 221

– 3-acetoxy-1-(2-aryl-2-oxoethyl)-quinuclidinium bromides + hydrogen/palladium on carbon 221

– 1-benzyl-1,2,3,6-tetrahydropyridines + (1.) carbonyl chloride (or phenyl carbonochloridate), (2.) acid 565 (3095)

Thermal Dealkylation

– 1-methylpyridinum iodides 698 (3211)

- *O*-Alkyl Compounds

Thermal Dealkylation

– 4-alkoxy-1-methylpyridinium iodides 227 (2778)

● Dealkylthiolation

- *C*-Alkylthio Compounds

– alkyl diphenylmethyl sulfides + lithium alanate/copper(II) chloride 366 (2883)

– 3-methylthioindoles + Raney nickel 816 (3308), 819 (3319)

– 2-methylthiomethylanilines + hydrogen + Raney nickel 685 (3161)

● Deamination

– – hydrogenolytic deamination of Mannich bases 750

– 2-amino-1-bromophenanthrene + (1.) nitrous acid, (2.) aqueous phosphoric acid 610

– 3-dialkylaminopropananilides + (1.) methyliodide, (2.) base 773

– Mannich bases 745

● Dearylthiolation

- *C*-Arylthio Compounds

– 2,4-dialkyl-5-phenylthioimidazoles + Raney nickel 374 (2923)

– diphenylmethyl phenyl sulfides + lithium alanate/copper(II) chloride 366 (2883)

- *N*-Arylthio Compounds

– *N,N*-diarylthio-1-aminoalkanes + hydrogen chloride 229 (2785)

– *N,N*-diphenylthio-1-aminoalkanes + ethylmercaptan 229 (2784, 2785)

● Decarbonylation

- Quinones

– 3,5-di-*t*-butyl-*o*-benzoquinone 614

● Decarboxylation

- Alkanoic Acids

Oxidative Decarboxylation

– 4-aryl-4-oxobutanoic acids + lead(IV) acetate/copper(II) acetate 541

– 2-hydroxyalkanoic acids + cerium(IV) ammonium nitrate 350

- Carbamic Acid Esters

Decarboxylation using Acids or Bases

– 4-nitrophenyl *N*-hydroxycarbamate + (1.) base, (2.) acid 551 (3040)

- *C*-Formyloxy Compounds

Thermal or Catalytic Decarboxylation

– 1,4-diformyloxy-2-alkynes + copper + heat 614

- Heterocyclic Carboxylic Acids

Thermal or Catalytic Decarboxylation

– 4-carboxy-2,7-naphthyridine (+ copper) 46

- Miscellaneous Carboxylic Acids

Oxidative Decarboxylation

– cycloheptatriene-7-carboxylic acid + cerium(IV) ammonium nitrate 350

Thermal or Catalytic Decarboxylation

– 1,3-dialkyl-2-oxo-2,3-dihydroimidazole-4-acetic acids 291

● Dechlorination

– dialkylaminotrichloroethylenes + butyllithium 402

– tetrachloroethylene + oxirane + quaternary aminium compounds 450

● Decyanation

– 3-cyano-2-cyclohexyloctahydro-1,2-benzoxazines + (1.) silver tetrafluoroborate, (2.) sodium tetraphenylborate 550 (3038)

● Dehydration

- Alcohols

Chemical Dehydration

– 1,3-bis[1-naphthyl]-1,3-diphenyl-3-hydroxypropene + chiral camphor-10-sulfonic acid 26

– dialkylphenylcarbinols + lithium alanate + aluminum chloride 113 (2668)

– 3,7-dihydroxy-3,7-diphenyl-2,2,8,8-tetramethyl-4-nonynes + (+)-bromocamphorsulfonic acid 29

– sterically hindered alcohols + (1.) 4-methylphenyl carbonochloridothioate, (2.) heat 624 (3102)

Thermal or Catalytic Dehydration

– 2-hydroxyalkanes on thorium(IV) oxide, thermally 175 (2716)

– 2-hydroxymethylalkanoic acids (+ phosphoric acid) 60 (2624)

- Carboxamides

Chemical Dehydration

– – with phosphonitrile dichloride 554 (3055)

– *N*-substituted formamides + triphenylphosphine + diethyl diazenedicarboxylate 435 (2958)

- Carboxylic Acids

Chemical Dehydration

– – with cyanogen bromide + pyridine 630 (3129)

- Heterocyclic Compounds

Chemical Dehydration

– 3-alkyl-4,5-diphenyl-4-hydroxy-2-oxotetrahydro-1,3-oxazoles + trifluoroacetic acid 240 (2833)

– 4-hydroxy-2-oxohexahydropyrimidines + acetic anhydride 270

– 5-hydroxy-1-oxo-5-phenyl-2,3,4,5-tetrahydro-1*H*-2-benzazepines + sulfuric acid 507 (3025)

- Oximes

Chemical Dehydration

– aldoximes + phosphoronitrile dichloride 809 (3276)

– aldoximes + trichloro-1,3,5-triazine 367 (2890)

- Miscellaneous Compounds

Chemical Dehydration

– diethyl 1-alkyl-1-hydroxyalkanephosphonates + thionyl chloride/pyridine 364

● Dehydroalkoxylation

– 4-alkoxy-2-oxohexahydropyrimidines + acetic anhydride/pyridine 270

– chloroacetaldehyde diethyl acetal + sodium amide 318 (2850)

– dialkyl 1,1-dialkoxyethanephosphonates 547

● Dehydroamination

– *gem*-*N*-benzoylaminomethylcycloalkanes + phosphorus(V) oxide 114 (2674)

– *gem*-*N*-benzoylaminomethylcycloalkanes + thionyl chloride 114 (2674)

● Dehydrobromination

- Bromoalkanes

Chemical Dehydrobromination

– 1-bromo-2-phenylethane + aqueous sodium hydroxide + tributylaminium chloride 449

– 3,4-dibromo-7,8-dioxobicyclo-[4.2.0]oct-1(6)-ene + DBN 212

– triethyl 2-bromoorthoalkanoates + potassium *t*-butoxide 207

– triethyl 2,3-dibromoorthopropanoate + potassium *t*-butoxide 207

Thermal or Catalytic Dehydrobromination
– 1,4-dibromotetralins, on silica gel 317 (2846)
- **Bromoalkenes**
Chemical Dehydrobromination
– triethyl 2-bromoorthopropenoate + potassium *t*-butoxide 207
- **Organic Bromide Salts**
Chemical Dehydrobromination
– *N*-acetylaminodialkylsulfonium bromides + triethylamine 322 (2865)
● **Dehydrochlorination**
- **Chloralkanes**
Chemical Dehydrochlorination
– 1,1-bis[4-fluorophenyl]-4-chloro-1-butene + aqueous sodium hydroxide + benzyltriethylaminium chloride 449
– 2-chlorobornane + silver nitrate/dimethyl sulfoxide 367 (2888)
– 1,7-dichloro-1,7-dimethyl-4-isopropylnaphthalene + silver nitrate/dimethyl sulfoxide 367 (2888)
– tris[2-chloroalkyl] orthocarboxylates + sodium methoxide 808 (3271)
- **Chloroalkenes**
Chemical Dehydrochlorination
– 1-chloro-4-cyclohexylbutadiene + methyllithium 800 (3237)
– 2-chloro-1,1-dicyclopropyl ethylene + butyllithium 318 (2848)
● **Dehydrogenation (Elimination of Elemental Hydrogen)**
for Chemical dehydrogenation, *refer to:* Oxidation
- **Aromatization of Cyclic Systems**
Thermal or Catalytic Dehydrogenation
– 2,3-dialkoxycarbonyl-3,3a-dihydropyrazolo[1,5-*a*]pyridines + palladium on carbon 634 (3147)
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– cycloalkanones + palladium(II) compounds 177 (2727)
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● **Dehydrohalogenation**
Chemical Dehydrohalogenation
– glycosyl halides + triethyl phosphite 700 (3221)
● **Dehydrosulfurization**
– 1-aminothiocarbonyl-1-cyanoisochroman + triphenylphosphine + carbon tetrachloride + triethylamine 297
● **Demercuration**
– 3-chloromercurio-4-methoxy-2-pentene + sodium borohydride 36
● **Desilylation**
– alkyl *t*-butyldimethylsilyl ethers + tetrabutylaminium fluoride 372 (2912)
– 3-aryl-5-trimethylsilylethynylpyrazoles + aqueous base 47
– 1-trimethylsilyl-3-alken-1-ynes + potassium fluoride dihydrate 800 (3239)
● **Desulfonylation**
- ***C*-Sulfonyl Compounds**
Chemical Desulfonylation
– 1-phenylsulfonylalkenes + aluminum amalgam/water 801 (3241)
Thermal or Catalytic Desulfonylation
– arenesulfonyl halides + rhodium-, platinum-, or iridium complexes + heat 55 (2606)
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- ***N*-Sulfonyl Compounds**
Chemical Desulfonylation
– 1-alkylsulfonylindoles + base 561 (3081)
– 1-arylsulfonylindoles + base 561 (3081)
– 1-chlorosulfonyl-2-oxoazetidines + benzenethiol + pyridine 342
– *N*-tosylsulfilimines + sulfuric acid 182 (2749)
● **Desulfurization**
- ***S*-Heterocyclic Compounds**
Thermal or Catalytic Desulfurization
– 6-phenylcephams + Raney nickel 439 (2977)
– 5-phenylpenams + Raney nickel 439 (2977)
– thiophenes + a nickel boride catalyst *in situ* 317 (2843)
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– 4,4-dialkyl-3,5-dioxo-1,2-dithiolanes + triphenylphosphine 559 (3074)
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- ***C*-Deuteration**
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- ***N*-(1,1-Dialkoxyalkylation)**
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- ***C*-(1,1-Dithioalkylation)**
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Replacement of Other Substituents
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- *C*-**Hydroxycarbonylation**
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- *C*-**Hydroxylation**
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- *N*-**(1-Iminoalkylation)**
Replacement of Hydrogen
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- *C*-**Iminomethylation**
Replacement of Hydrogen
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- *C*-**Nitrosation**
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– lactams + alkyl hydroperoxides 119 (2697)

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with Ruthenium(VIII) Compounds
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with Silver(I) Compounds
– 3,4-dihydroxystilbenes + silver carbonate on cellite 499 (2995)

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C-Metal Compounds + Coupling
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– styrylmagnesium bromide + thionyl chloride 550 (3037)
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– ethynyltrialkylsilanes + copper(I)-tertiary amine complexes + oxygen 805 (3259)
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– 3-oxo-2-phenylalkanenitriles + copper(II) chloride hydroxide + oxygen 59 (2622)
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– lithiotriarylthiomethanes + iodine 322 (2866)
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– *N*-phenylthiobenzenesulfenamide + butenone + benzyltrimethylaminium hydroxide 228 (2784)
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- **7 → 9 Ring Atoms**

– C_9 –

- *$C_7 + C_2$*

– dimethyl-(2-oxocycloheptylidene)-sulfurane + activated alkynes 501 (3000)

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- **Bicyclo[2.2.2] Systems → 6,6-Systems, fused**

– C_5N-C_5O –

O–C–C–C–C–C/N–C–C–C–C–C

- *Thermal or Catalytic Transformation*

– 3-methoxycarbonyl-1-azoniabicyclo[2.2.2]oct-2-ene halides + heat 506 (3022)

- **Bicyclo[3.1.1] Systems → Cyclo-6 Systems**

– C_6 –

- *Chemical Transformation*

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– C_9 –

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– 9,9-dibromodicyclo[6.1.0]-nonane + butyllithium 32

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– bicyclo[9.1.0]non-4-ene + dibenzonitrile-palladium(II) chloride 366 (2885)

- **3,6-Systems, fused → Cyclo-7-Systems**

– C_7 –

- *Chemical Transformation*

– 1,1-dihalo-1a,2,3,6b-tetrahydro-1*H*-cyclopropa[*e*] [1]-benzothiophenes + base 812 (3291)

- *Thermal or Catalytic Transformation*

– 1,1-dihalo-1a,2,3,6b-tetrahydro-1*H*-cyclopropa[e][1]-benzothiophenes + heat 812 (3291)

- **3,8-Systems, fused → 5,6-Systems, fused**

– C_5-C_6 –

- *Chemical Transformation*

– 9,9-dibromobicyclo[6.1.0]-non-4-ene + acetic anhydride + zinc chloride 801 (3240)

- **Tricyclo[4.2.1.$0^{2,4}$] → Bicyclo-[4.2.1] Systems**

– C_5-C_7 –

- *Thermal or Catalytic Transformation*

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- **Tricyclo[5.2.1.$0^{2,6}$] → Tricyclo[3.3.1.$1^{3,7}$] Systems (Adamantane Systems)**

– C_6-C_6-C_6 –

Chemical Transformation

– tetrahydrodicyclopentadiene + hexafluoroantimonic acid 488

● **Silylation**

- ***C*-Silylation**

Additive Silylation

– 1-alkenes + trichlorosilane + noble-metal catalysts 372 (2913)

– 1-alkenes + triethoxysilane + noble-metal catalysts 372 (2913)

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– benzene + chlorotrimethylsilane + lithium 431 (2943)

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Replacement of Halogen

– alkyl halides + alkyldiarylsilanes + isopropylmagnesium chloride 558 (3071)

– alkyl halides + aryldialkylsilanes + isopropylmagnesium chloride 558 (3071)

– *N,N*-bis[trimethylsilyl]-4-bromoaniline + (1.) butyllithium, (2.) dichlorosilanes 223

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- ***O*-Silylation**

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– 1-alkenyl ketones + tertiary silanes + tris[triphenylphosphine]-rhodium chloride 686 (3164)

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– 4-aminobenzoic acid + chlorotrimethylsilane + base 217

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– dialkyl carbonates + triphenylsilanes + nickel catalysts 234 (2806)

- ***Si*-Silylation**

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- ***O*-Stannylation**

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– ***C*-Sulfonylation**

Additive Sulfonylation

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Replacement of Hydrogen

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- ***N*-Sulfonylation**

Replacement of Hydrogen

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- ***C*-Sulfonyloxylation**

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Replacement of Halogen

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● **Wittig Reaction**

see: Carbonyl Olefination

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